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GAS SENSOR

Abstract

Disclosed herein is a gas sensor that includes: first and second thermistors; first and second heaters configured to heat the first and second thermistors, respectively; and a control circuit. The control circuit is configured to, in a gas measurement operation, generate an output signal based on a detection signal appearing at a connection point between the first and second thermistors by heating the first and second heaters. The control circuit is configured to, in a resistance measurement operation, measure a resistance value of the first thermistor with a series connection of the first and second thermistors disconnected. The control circuit is configured to correct a value of the output signal based on the resistance value of the first thermistor measured in the resistance measurement operation.

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Background/Summary

BACKGROUND OF THE ART

Field of the Art

[0001] The present disclosure relates to a gas sensor.

Description of Related Art

[0002] International Publication WO 2020/031517 discloses a gas sensor configured to calculate the concentration of a gas to be detected based on the level of a detection signal appearing at the connection point of two series-connected thermistors. The gas sensor described in International Publication WO 2020/031517 heats a thermistor constituting a detection element and a thermistor constituting a reference element to 150° C. and 300° C., respectively, to acquire a detection signal and then heats the thermistor as the detection element and thermistor as the reference element to 300° C. and 150° C., respectively, to eliminate a difference in thermal history between the two thermistors.

[0003] However, even in the gas sensor described in Patent Document 1, the temperature characteristics of the thermistor may change with age.

SUMMARY

[0004] A gas sensor according to the present disclosure includes: a detection circuit including a first thermistor and a second thermistor; a first heater configured to heat the first thermistor; a second heater configured to heat the second thermistor; and a control circuit configured to control a connection relation in the detection circuit and the first and second heaters. The control circuit is configured to, in a gas measurement operation, generate an output signal indicating a concentration of a gas to be measured based on a detection signal appearing at a connection point between the first and second thermistors by connecting the first and second thermistors in series and heating the first and second heaters. The control circuit is configured to, in a resistance measurement operation, measure a resistance value of the first thermistor with a series connection of the first and second thermistors disconnected. The control circuit is configured to correct a value of the output signal based on the resistance value of the first thermistor measured in the resistance measurement operation.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The above features and advantages of the present disclosure will be more apparent from the following description of some embodiments taken in conjunction with the accompanying drawings, in which:

[0006] FIG. **1** is a circuit diagram illustrating the configuration of a gas sensor **1** according to a first embodiment of the technology described herein;

[0007] FIGS. **2**A and **2**B are circuit diagrams of the resistance measuring circuit **11**;

[0008] FIG. **3** is a timing chart for explaining the operation of the gas sensor **1**;

[0009] FIG. **4** is a graph characteristics of the thermistors Rd**1** and Rd**2**;

[0010] illustrating the temperature

[0011] FIG. **5** is a graph illustrating the relation between the temperature of the thermistors Rd**1**, Rd**2** and their sensitivity to CO_2 gas;

[0012] FIG. **6** is a circuit diagram illustrating the configuration of a gas sensor **2** according to a second embodiment of the technology disclosed herein;

[0013] FIG. **7** is a timing chart for explaining the operation of the gas sensor **2**;

[0014] FIG. **8** is a circuit diagram illustrating the configuration of a gas sensor **3** according to a third embodiment of the technology disclosed herein; and

[0015] FIG. **9** is a circuit diagram illustrating the configuration of a gas sensor **4** according to a fourth embodiment of the technology disclosed herein.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0016] The present disclosure describes a gas sensor in which a measurement error due to aging of the thermistor is reduced.

[0017] Some embodiments of the present disclosure will be explained below in detail with reference to the accompanying drawings.

[0018] FIG. **1** is a circuit diagram illustrating the configuration of a gas sensor **1** according to a first embodiment of the technology described herein.

[0019] As illustrated in FIG. **1**, the gas sensor **1** according to the first embodiment includes: a detection circuit **10** including thermistors Rd**1**, Rd**2** and resistance measurement circuits **11**, **12**; heaters MH**1** and MH**2** for heating the thermistors Rd**1** and Rd**2**, respectively; and a control circuit for controlling the detection circuit **10** and heaters MH**1** and MH**2**. Although not particularly limited, the gas sensor) **1** according to the present embodiment is a thermal conduction type gas sensor for detecting the concentration of CO.sub.2 gas in the atmosphere.

[0020] The detection circuit **10** includes the thermistors Rd**1** and Rd**2**, the resistance measurement circuits **11** and **12**, and switches SW**1** to SW**3**. The thermistors Rd**1** and Rd**2** are detection elements made of a material having a negative temperature coefficient of resistance, such as a composite metal oxide, amorphous silicon, polysilicon, or germanium. Both the thermistors Rd**1** and Rd**2** detect the concentration of CO.sub.2 gas, but have different operating temperatures, as described below. Here, the thermistor Rd**1** constitutes a detection element, and the thermistor Rd**2** constitutes a reference element.

[0021] As illustrated in FIG. **1**, the switch SW**1** is connected between a power supply **25** for supplying a power supply potential VDDS and the thermistor Rd**1**. The switches SW**2** and SW**3** are connected between the thermistors Rd**1** and Rd**2**. Thus, when the switches SW**1** to SW**3** are turned ON, the thermistors Rd**1** and Rd**2** are connected in series between the power supply and the ground. A potential appearing between the switches SW**2** and SW**3** in this state, i.e., a detection signal appearing at the connection point between the thermistors Rd**1** and Rd**2** is supplied to the control circuit **20**. On the other hand, when the switches SW**1** to SW**3** are turned OFF, the series connection of the thermistors Rd**1** and Rd**2** is released, and the thermistors Rd**1** and Rd**2** are separated from each other. The resistance measurement circuits **11** and **12** measure the resistance values of the thermistors Rd**1** and Rd**2**, respectively, in a state where the switches SW**1** to SW**3** are tuned OFF.

[0022] As illustrated in FIG. **2**A, the resistance measurement circuit **11** may have a configuration in which a constant current source **13** and a voltmeter **14** are connected in parallel between one end **11***a* and the other end **11***b*. With this configuration, when a constant current is made to flow from the constant current source **13** to the thermistor Rd**1** in a state where the thermistor Rd**1** is connected between the one end **11***a* and the other end **11***b*, a voltage to be generated between the one end **11***a* and the other end **11***b* is determined by the resistance value of the thermistor Rd**1**. This voltage is measured with the voltmeter **14** and supplied to the control circuit **20**. This allows the control circuit **20** to acquire the directly-measured resistance value of the thermistor Rd**1**.

[0023] Alternatively, as illustrated in FIG. **2**B, the resistance measurement circuit **11** may have a configuration in which a constant voltage source **15** and an ammeter **16** are connected in series between the one end **11***a* and the other end **11***b*. With this configuration, when a predetermined voltage is applied from the constant voltage source **15** to the thermistor Rd**1** in a state where the thermistor Rd**1** is connected between the one end **11***a* and the other end **11***b*, a current flowing between the one end **11***a* and the other end **11***b* is determined by the resistance value of the thermistor Rd**1**. This current is measured with the ammeter **16** and supplied to the control circuit **20**. This allows the control circuit **20** to acquire the directly-measured resistance value of the thermistor Rd**1**.

[0024] The same applies to the configuration of the resistance measurement circuit **12**, and the control circuit **20** can acquire the directly-measured resistance value of the thermistor Rd**2**.

[0025] The control circuit **20** includes an AD converter (ADC) **21**, DA converters (DAC) **22** and **23**, an MPU **24**, the power supply **25**, and a multiplexer **26**. The multiplexer **26** supplies, under the control of the MPU **24**, either a detection signal appearing at the connection point between the thermistors Rd**1** and Rd**2** or resistance measurement signals output respectively from the resistance measurement circuits **11** and **12** to the AD converter **21**. A plurality of the AD converters **21** may be used in place of the multiplexer **26**.

[0026] The MPU **24** controls the switches SW**1** to SW**3** to control the connection relation in the detection circuit **10**. The MPU **24** turns OFF the switches SW**1** to SW**3** during resistance measurement operation. The AD converter **21** sequentially AD-converts the resistance measurement signals supplied in this state from the resistance measurement circuits **11** and **12** and supplies the resultant signals to the MPU **24**. The MPU **24** calculates the resistance values of the thermistors Rd**1** and Rd**2** based on the AD-converted resistance measurement signals.

[0027] On the other hand, during gas measurement operation, the MPU **24** turns ON the switches SW**1** to SW**3**. The AD converter **21** AD-converts a detection signal appearing in this state at the connection point between the thermistors Rd**1** and Rd**2** and supplies the resultant signal to the MPU **24**. The MPU **24** calculates an output signal OUT indicating the concentration of CO.sub.2 gas based on the AD-converted detection signal. In the calculation of the output signal OUT, the value of the output signal OUT is corrected based on the resistance values of the thermistors Rd**1** and Rd**2** calculated during the resistance measurement operation.

[0028] The DA converters **22** and **23** DA-convert the digital value supplied from the MPU **24** to apply predetermined voltages to the heater resistors MH**1** and MH**2**, respectively. In other words, the heating temperatures of the heater resistors MH**1** and MH**2** are controlled by the MPU **24**.

[0029] The following describes the operation of the gas sensor **1** according to the present embodiment.

[0030] FIG. **3** is a timing chart for explaining the operation of the gas sensor **1** according to the present embodiment.

[0031] As illustrated in FIG. **3**, the gas sensor **1** according to the present embodiment performs the gas measurement operation in period T**1** and dummy heating operation in period T**2**. The gas measurement operation and dummy heating operation are performed alternately. Further, the gas sensor **1** performs the resistance measurement operation at time t**1**, which is the timing immediately before period T**1** in which the gas measurement operation is performed. During the resistance measurement operation, heating of the thermistors Rd**1** and Rd**2** by the heater resistors MH**1** and MH**2** is stopped. Therefore, the resistance measurement operation performed at time t**1** is executed with thermistors Rd**1** and Rd**2** under the environmental temperature.

[0032] In the present embodiment, a temperature signal TP indicating the current environmental temperature is supplied to the MPU **24**. This allows the MPU **24** to acquire the current environmental temperature and the resistance values of the thermistors Rd**1** and Rd**2** under the current environmental temperature and thereby to calculate, based on the thus acquired information, the resistance values of the thermistors Rd**1** and Rd**2** at a predetermined reference temperature (e.g., 25° C.). The MPU **24** stores therein design resistance values of the thermistors Rd**1** and Rd**2** at a predetermined reference temperature (e.g., 25° C.). The MPU **24** compares the design resistance values of the thermistors Rd**1** and Rd**2** and actually acquired resistance values thereof to correct the value of the output signal based on the resistance values of the thermistors.

[0033] In the gas measurement operation performed during period T**1**, the heater resistor MH**1** is heated to 150° C. and the heater resistor MH**2** is heated to 300° C. under the control of the MPU **24**. As illustrated in FIG. **4**, the temperature characteristics of thermistors Rd**1** and Rd**2** are different from each other, and they are designed such that the resistance value of the thermistor Rd**1** heated to 150° C. and the resistance value of the thermistor Rd**2** heated to 300° C. are close to each other. In the example illustrated in FIG. **4**, the resistance value of the thermistor Rd**1** heated to 150° C. is 5.1 kΩ, and the resistance value of the thermistor Rd**2** heated to 300° C. is 4.0 kΩ. The resistance value of the thermistor Rd**1** heated to 150° C. and the resistance value of the thermistor Rd**2** heated to 300° C. may be approximately the same.

[0034] FIG. **5** is a graph illustrating the relation between the temperature of the thermistors Rd**1**, Rd**2** and their sensitivity to CO.sub.2 gas. As can be seen from the graph of FIG. **5**, the sensitivity of the thermistors Rd**1** and Rd**2** to CO.sub.2 gas varies significantly depending on the temperature, and the sensitivity of the thermistors Rd**1**, Rd**2** to CO.sub.2 gas is almost zero in the temperature range below 40° C. or above 300° C. The sensitivity of the thermistors Rd**1**, Rd**2** to CO.sub.2 gas is maximum at about 150° C.

[0035] When CO.sub.2 gas is present in the measurement atmosphere with the thermistor Rd**1** as the detection element heated to 150° C., the heat dissipation characteristics of the thermistor Rd**1** change according to the concentration. Such a change appears as a change in the resistance value of the thermistor Rd**1**. On the other hand, even when CO.sub.2 gas is present in the measurement atmosphere with the thermistor Rd**2** as the reference element heated to 300° C., the heat dissipation characteristics of the thermistor Rd**2** hardly change according to the concentration. Therefore, the change in the resistance value of the thermistor Rd**2** heated to 300° C. due to the concentration of CO.sub.2 gas is sufficiently smaller than the change in the resistance value of the thermistor Rd**1** heated to 150° C. due to the concentration of CO.sub.2 gas. There is no problem if the resistance value of the thermistor Rd**2** heated to 300° C. due to the concentration of CO.sub.2 gas hardly changes.

[0036] As a result, the level of the detection signal appearing at the connection point between the thermistors Rd**1** and RD**2** changes according to the concentration of CO.sub.2 gas in the measurement atmosphere. The detection signal is supplied to the MPU **24** through the AD converter **21**, and the MPU **24** generates an output signal OUT indicating the concentration of CO.sub.2 gas based on the supplied detection signal. In calculating the output signal OUT, a correction is made based on the result of the resistance measurement operation performed at time t**1**.

[0037] As described above, the resistance measurement operation performed at time t**1** is performed under the environmental temperature at which the sensitivity of the thermistors Rd**1** and Rd**2** to CO.sub.2 gas is almost zero, so that the resistance values of the thermistors Rd**1** and Rd**2** can be accurately measured regardless of the concentration of CO.sub.2 gas in the environment during the resistance measurement operation. Therefore, it is possible to calculate the resistance value of the thermistor Rd**1** heated to 150° C. and the resistance value of the thermistor Rd**2** heated to 300° C. when the concentration of CO.sub.2 gas is the same as the concentration of CO.sub.2 gas in the atmosphere under normal conditions (about 400 ppm). As a result, the output signal OUT indicating the concentration of CO.sub.2 gas can be calculated using the detection signal that actually appears at the connection point between the thermistors Rd**1** and Rd**2**, the resistance value under normal conditions of the thermistor Rd**1** heated to 150° C., and the resistance value under normal conditions of the thermistor Rd**2** heated to 300° C.

[0038] In the dummy heating operation performed in period T**2**, the heater resistor MH**1** is heated to 300° C., and the heater resistor MH**2** is heated to 150° C. under the control of the MPU **24**. This eliminates the thermal history difference between the thermistors Rd**1** and Rd**2** during the gas measurement operation performed in period T**1**.

[0039] In this way, the gas sensor **1** according to the present embodiment actually measures the resistance values of the thermistors Rd**1** and Rd**2** using the resistance measurement circuits **11** and **12**, so that even if the thermistors Rd**1** and Rd**2** have changed with age, the value of the output signal OUT can be properly corrected. Moreover, the measurement of the resistance values of the thermistors Rd**1** and Rd**2** using the resistance measurement circuits **11** and **12** is performed with heating by the heater resistors MH**1** and MH**2** stopped, so there is no measurement error due to the concentration of CO_2 gas present in the atmosphere. In addition, by performing the resistance measurement operation immediately before the period T**1**, the influence of residual heat is eliminated, and it is possible to measure the resistance values of the thermistors Rd**1** and Rd**2** under a more accurate environmental temperature.

[0040] However, if the actual environmental temperature is significantly deviated from a predetermined reference temperature (e.g., 25° C.), the resistance measurement operation may be affected by CO_2 gas. Therefore, the MPU **24** may disable the resistance measurement operation when the environmental temperature is outside the predetermined temperature range, e.g., when it exceeds 40° C. In this case, the resistance measurement operation itself may be skipped, or the calculation operation after the resistance measurement operation may be skipped. Alternatively, although the resistance measurement operation and the calculation operation are performed, the values obtained thereby may be ignored.

[0041] In addition, in the present embodiment, the gas measurement operation is performed in period T**1**, and the dummy heating operation is performed in period T**2**, so that the thermistors Rd**1** and Rd**2** undergo approximately the same aging change. Taking this into consideration, it is not essential to actually measure the resistance values of both thermistors Rd**1** and Rd**2**, and it is also possible to actually measure the resistance value of only one of the thermistors Rd**1** and Rd**2** and calculate the resistance value of the other thermistor Rd**2** based on that result. For example, by measuring the resistance value of the thermistor Rd**1** at room temperature, both the resistance value of the thermistor Rd**1** heated to 150° C. and the resistance value of the thermistor Rd**2** heated to 300° C. may be calculated.

[0042] In the present embodiment, heating by the heater resistors MH**1** and MH**2** is stopped during the resistance measurement operation, but heating by the heater resistors MH**1** and MH**2** may be performed as long as the sensitivity of the thermistors Rd**1** and Rd**2** to CO_2 gas is sufficiently low. As an example, the thermistors Rd**1** and Rd**2** may be heated to 300° C. by the heater resistors MH**1** and MH**2** during the resistance measurement operation.

[0043] FIG. **6** is a circuit diagram illustrating the configuration of a gas sensor **2** according to a second embodiment of the technology disclosed herein.

[0044] As illustrated in FIG. **6**, the gas sensor **2** according to the second embodiment differs from the gas sensor **1** according to the first embodiment in that the detection circuit **10** includes a thermistor Rd**3** and a fixed resistor R**3**. Other basic configurations are the same as those of the gas sensor **1** according to the first embodiment, so the same reference numerals are given to the same elements, and overlapping description will be omitted.

[0045] The thermistor Rd**3** and fixed resistor R**3** are connected in series between the power supply **25** and the ground, and a temperature signal TP appears the connection point therebetween. The temperature signal TP is supplied to the AD converter **21** through the multiplexer **26**. The AD converter **21** AD-converts the temperature signal TP and supplies the resultant signal to the MPU **24**.

[0046] FIG. **7** is a timing chart for explaining the operation of the gas sensor **2** according to the present embodiment.

[0047] As illustrated in FIG. **7**, the gas sensor **2** according to the present embodiment acquires the temperature signal TP at time t**2**, which is the timing immediately before period T**1**, and performs the resistance measurement operation at time t**1**. The order of time t**1** and time t**2** does not matter, but it is preferable that the time difference between the two is small. This makes it possible to more accurately measure the environmental temperature during the resistance measurement operation.

[0048] As exemplified in the second embodiment, the detection circuit **10** itself may generate the temperature signal TP.

[0049] FIG. **8** is a circuit diagram illustrating the configuration of a gas sensor **3** according to a third embodiment of the technology disclosed herein.

[0050] As illustrated in FIG. **8**, the gas sensor **3** according to the third embodiment differs from the gas sensor **1** according to the first embodiment in that the detection circuit **10** includes fixed resistors R**1** and R**2** and switches SW**11** and SW**12**. Other basic configurations are the same as those of the gas sensor **1** according to the first embodiment, so the same reference numerals are given to the same elements, and overlapping description will be omitted.
[0051] The switches SW**11** and SW**12** each have one common node a and two selection nodes b and C, and one of the selection nodes b and c is connected to the common node a. For both of the switches SW**1** and SW**2**, the selection node b is selected during the gas measurement operation and dummy heating operation, and the selection node c is selected during resistance measurement operation.
[0052] As illustrated in FIG. **8**, the common node a of the switch SW**11** is connected to one end of thermistor Rd**1**, the selection node b of the switch SW**11** is connected to the selection node b of the switch SW**12**, and the selection node c of the switch SW**11** is connected to one end of the fixed resistor R**1**. The other end of the thermistor Rd**1** is connected to the power supply **25** that supplies a power supply potential VDDS, and the other end of the fixed resistor R**1** is connected to a wiring to which a ground potential GND is supplied. The common node a of the switch SW**12** is connected to one end of thermistor Rd**2**, the selection node b of the switch SW**12** is connected to the selection node b of the switch SW**11**, and the selection node c of the switch SW**12** is connected to one end of the fixed resistor R**2**. The other end of the fixed resistor R**2** is connected to the power supply **25** that supplies a power supply potential VDDS, and the other end of the thermistor Rd**2** is connected to a wiring to which a ground potential GND is supplied.
[0053] As a result, during the gas measurement operation and dummy heating operation in which the selection node b is selected, the thermistors Rd**1** and Rd**2** are connected in series between the power supply **25** and the ground. On the other hand, during the resistance measurement operation in which the selection node c is selected, the thermistor Rd**1** and fixed resistor R**1** are connected in series between the power supply **25** and the ground, and the fixed resistor R**2** and thermistor Rd**2** are connected in series between the power supply **25** and the ground. As a result, during the resistance measurement operation, the resistance value of the thermistor Rd**1** can be calculated based on the potential that appears at the connection point between the thermistor Rd**1** and the fixed resistor R**1**, and the resistance value of the thermistor Rd**2** can be calculated based on the potential that appears at the connection point between the fixed resistor R**2** and the thermistor Rd**2**.
[0054] FIG. **9** is a circuit diagram illustrating the configuration of a gas sensor **4** according to a fourth embodiment of the technology disclosed herein.
[0055] As illustrated in FIG. **9**, the gas sensor **4** according to the fourth embodiment differs from the gas sensor **3** according to the third embodiment in that the detection circuit **10** includes a thermistor Rd**3** and a fixed resistor R**3**. Other basic configurations are the same as those of the gas sensor **3** according to the third embodiment, so the same reference numerals are given to the same elements, and overlapping description will be omitted.
[0056] The thermistor Rd**3** and fixed resistor R**3** are connected in series between the power supply **25** and the ground, and the temperature signal TP appears at the connection point therebetween. The temperature signal TP is supplied to the AD converter **21** through the multiplexer **26**. The AD converter **21** AD-converts the temperature signal TP and supplies the resultant signal to the MPU **24**.
[0057] The operation of the gas sensor **4** according to the present embodiment is as illustrated in FIG. **7**, where the temperature signal TP is acquired at time t**2**, which is the timing immediately before the period T**1**, and the resistance measurement operation is performed at time t**1**.
[0058] While some embodiments of the technology according to the present disclosure have been described, the technology according to the present disclosure is not limited to the above embodiments, and various modifications may be made within the scope of the present disclosure, and all such modifications are included in the technology according to the present disclosure.

[0059] For example, although the measurement target gas is CO.sub.2 gas in the above embodiments, the present invention is not limited to this. Further, the sensor part used in the present invention need not necessarily be a thermal conduction type sensor, but may be a sensor of other types such as a catalytic combustion type. As an example, when the measurement target gas is CO gas, a catalytic combustion type sensor part can be used.
[0060] The technology according to the present disclosure includes the following configuration examples, but not limited thereto.
[0061] A gas sensor according to the present disclosure includes: a detection circuit including a first thermistor and a second thermistor; a first heater configured to heat the first thermistor; a second heater configured to heat the second thermistor; and a control circuit configured to control a connection relation in the detection circuit and the first and second heaters. The control circuit is configured to, in a gas measurement operation, generate an output signal indicating a concentration of a gas to be measured based on a detection signal appearing at a connection point between the first and second thermistors by connecting the first and second thermistors in series and heating the first and second heaters. The control circuit is configured to, in a resistance measurement operation, measure a resistance value of the first thermistor with a series connection of the first and second thermistors disconnected. The control circuit is configured to correct a value of the output signal based on the resistance value of the first thermistor measured in the resistance measurement operation. Since the resistance value of the first thermistor is thus actually measured, it is possible to correct a measurement error caused by aging of the first and second thermistors.
[0062] In the above gas sensor, the control circuit may be configured to stop heating the first heater during the resistance measurement operation. This makes it possible to measure the resistance value of the first thermistor under the environmental temperature.
[0063] In the above gas sensor, the control circuit may be configured to calculate a resistance value of the first thermistor at a predetermined temperature based on the resistance value of the first thermistor measured in the resistance measurement operation and an environmental temperature. This makes it possible to more accurately calculate the resistance value of the first thermistor at a predetermined temperature.
[0064] In the above gas sensor, the control circuit may be configured to disable a measurement of the resistance value of the first thermistor when the environmental temperature is outside a predetermined temperature range. This makes it possible to avoid correcting the output signal based on the resistance value of the first thermistor calculated under an environment with a large measurement error.
[0065] In the above gas sensor, the control circuit may be configured to further measure a resistance value of the second thermistor with disconnecting the series connection of the first and second thermistors during the resistance measurement operation and may be configured to correct the value of the output signal based on the resistance values of the first and second thermistors. Since the resistance values of the first and second thermistors are thus actually measured, it becomes possible to more accurately correct a measurement error caused by aging of the first and second thermistors.
[0066] In the above gas sensor, the control circuit may be configured to stop heating the second heater during the resistance measurement operation. This makes it possible to measure the resistance value of the second thermistor under the environment temperature.
[0067] In the above gas sensor, the detection circuit may further include a switch connected between first thermistor and the second thermistor, and the control circuit may be configured to turn ON the switch during the gas measurement operation and turn OFF the switch during the resistance measurement operation. This makes it possible to actually measure the resistance value of the first thermistor using a resistance measurement circuit.
[0068] In the above gas sensor, the detection circuit may further include a first fixed resistor, and the control circuit may be configured to measure the resistance value of the first thermistor based

on a potential appearing at a connection point between the first thermistor and the first fixed resistor by connecting the first thermistor and the first fixed resistor in series during the resistance measurement operation. This makes it possible to actually measure the resistance value of the first thermistor without using the resistance measurement circuit.

[0069] In the above gas sensor, the detection circuit may further include a second fixed resistor, and the control circuit may be configured to measure a resistance value of the second thermistor based on a potential appearing at a connection point between the second thermistor and the second fixed resistor by connecting the second thermistor and the second fixed resistor in series during the resistance measurement operation. This makes it possible to actually measure the resistance value of the second thermistor without using the resistance measurement circuit.

Claims

1. A gas sensor comprising: a detection circuit including a first thermistor and a second thermistor; a first heater configured to heat the first thermistor; a second heater configured to heat the second thermistor; and a control circuit configured to control a connection relation in the detection circuit and the first and second heaters, wherein the control circuit is configured to: in a gas measurement operation, generate an output signal indicating a concentration of a gas to be measured based on a detection signal appearing at a connection point between the first and second thermistors by connecting the first and second thermistors in series and heating the first and second heaters; in a resistance measurement operation, measure a resistance value of the first thermistor with a series connection of the first and second thermistors disconnected; and correct a value of the output signal based on the resistance value of the first thermistor measured in the resistance measurement operation.

2. The gas sensor as claimed in claim 1, wherein the control circuit is configured to stop heating the first heater during the resistance measurement operation.

3. The gas sensor as claimed in claim 2, wherein the control circuit is configured to calculate a resistance value of the first thermistor at a predetermined temperature based on the resistance value of the first thermistor measured in the resistance measurement operation and an environmental temperature.

4. The gas sensor as claimed in claim 3, wherein the control circuit is configured to disable a measurement of the resistance value of the first thermistor when the environmental temperature is outside a predetermined temperature range.

5. The gas sensor as claimed in claim 1, wherein the control circuit is configured to further measure a resistance value of the second thermistor with disconnecting the series connection of the first and second thermistors in the resistance measurement operation; and wherein the control circuit is configured to correct the value of the output signal based on the resistance values of the first and second thermistors.

6. The gas sensor as claimed in claim 5, wherein the control circuit is configured to stop heating the second heater during the resistance measurement operation.

7. The gas sensor as claimed in claim 1, wherein the detection circuit further includes a switch connected between the first thermistor and the second thermistor, and wherein the control circuit is configured to turn ON the switch during the gas measurement operation and turn OFF the switch during the resistance measurement operation.

8. The gas sensor as claimed in claim 1, wherein the detection circuit further includes a first fixed resistor, and wherein the control circuit is configured to measure the resistance value of the first thermistor based on a potential appearing at a connection point between the first thermistor and the first fixed resistor by connecting the first thermistor and the first fixed resistor in series during the resistance measurement operation.

9. The gas sensor as claimed in claim 8, wherein the detection circuit further includes a second fixed resistor, and wherein the control circuit is configured to measure a resistance value of the second thermistor based on a potential appearing at a connection point between the second thermistor and the second fixed resistor by connecting the second thermistor and the second fixed resistor in series during the resistance measurement operation.