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(54) **CAMERA MODULE INCLUDING LIQUID LENS, AND CONTROL METHOD THEREOF**

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CPC ***G02B 7/028*** (2013.01); ***G02B 3/12*** (2013.01); ***H04N 23/55*** (2023.01); ***H05B 3/0019*** (2013.01)

(58) **Field of Classification Search**
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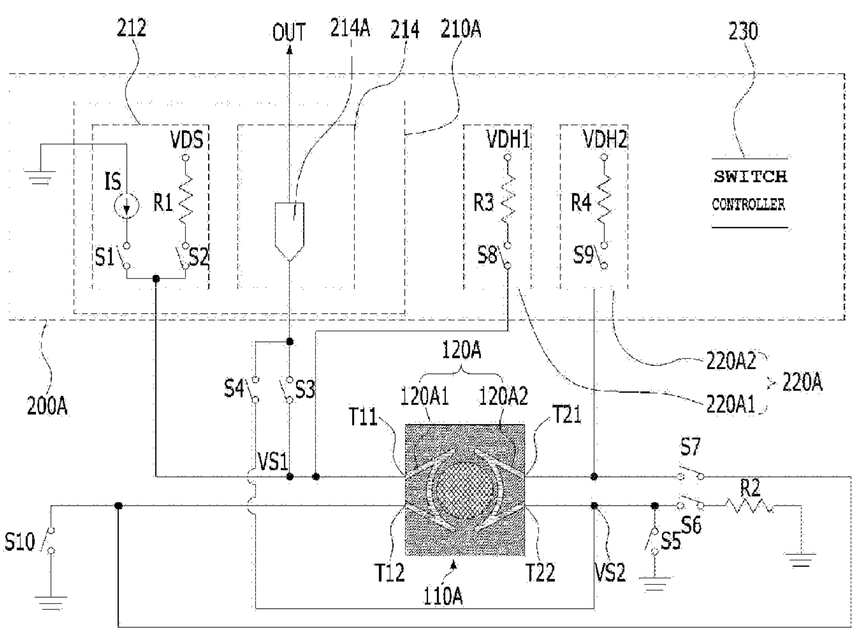
Primary Examiner — Ricky L Mack
Assistant Examiner — K Muhammad
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A camera module includes a liquid lens including a first plate and an individual electrode disposed on a first surface of the first plate; a resistor disposed on the first surface of the first plate so as to be spaced apart from the individual electrode; and a temperature sensor connected to the resistor and configured to sense a temperature of the liquid lens and a heating controller connected to the resistor and configured to control a temperature of the liquid lens.

19 Claims, 14 Drawing Sheets



(51) **Int. Cl.**
H04N 23/55 (2023.01)
H05B 3/00 (2006.01)

(58) **Field of Classification Search**
CPC H05B 3/0019; H05B 3/84; G03B 17/12; G03B 17/55
See application file for complete search history.

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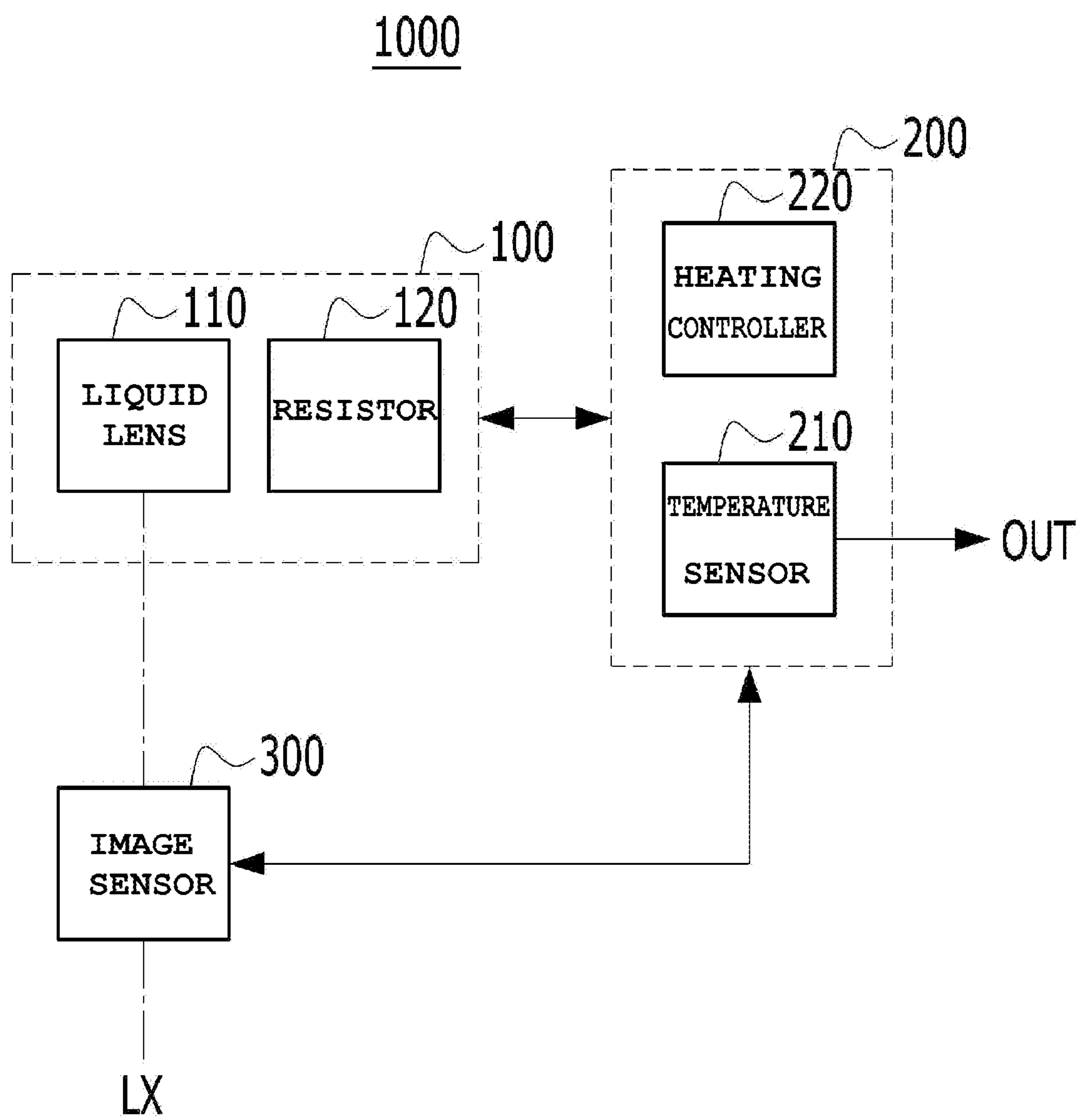
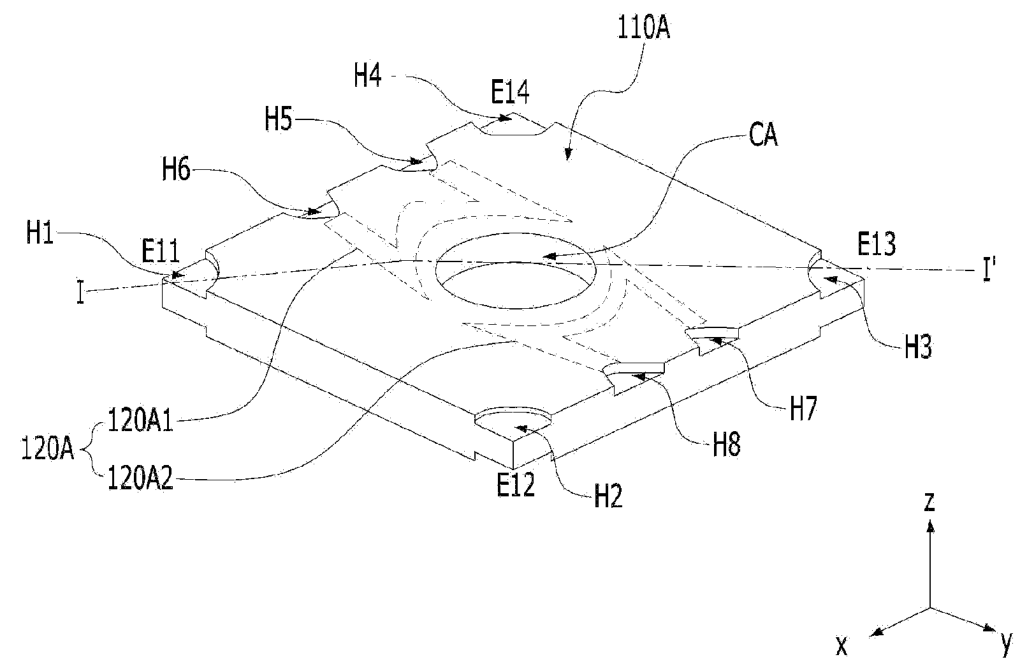
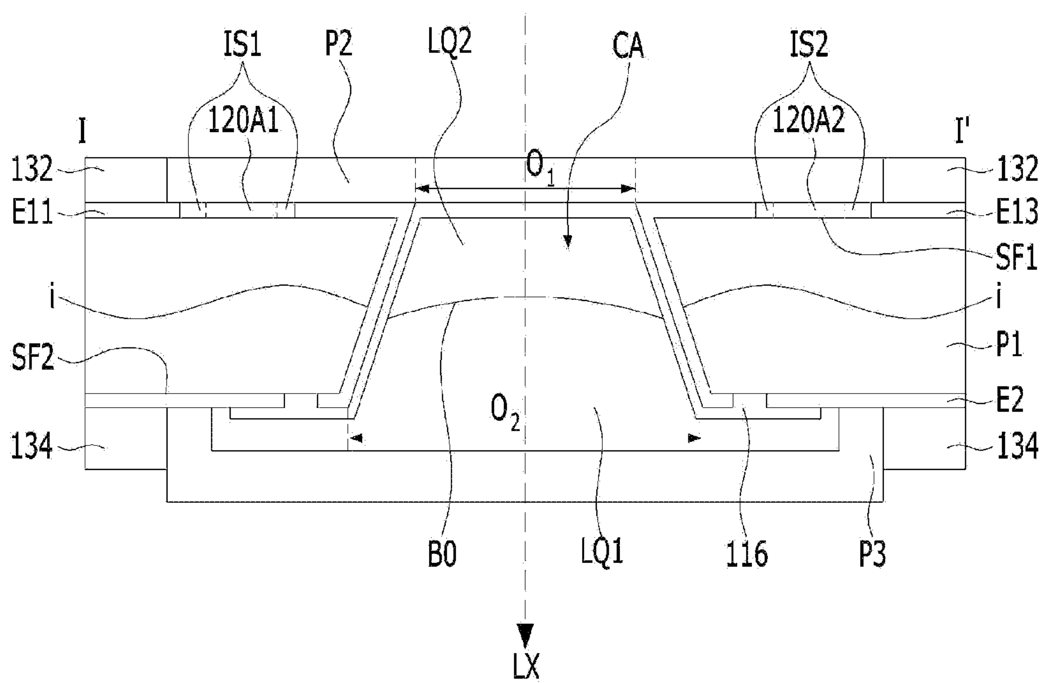
【FIG. 1】


1000
200
220
HEATING CONTROLLER
100
110
120
LIQUID LENS
RESISTOR
210
TEMPERATURE SENSOR
OUT
300
IMAGE SENSOR
LX

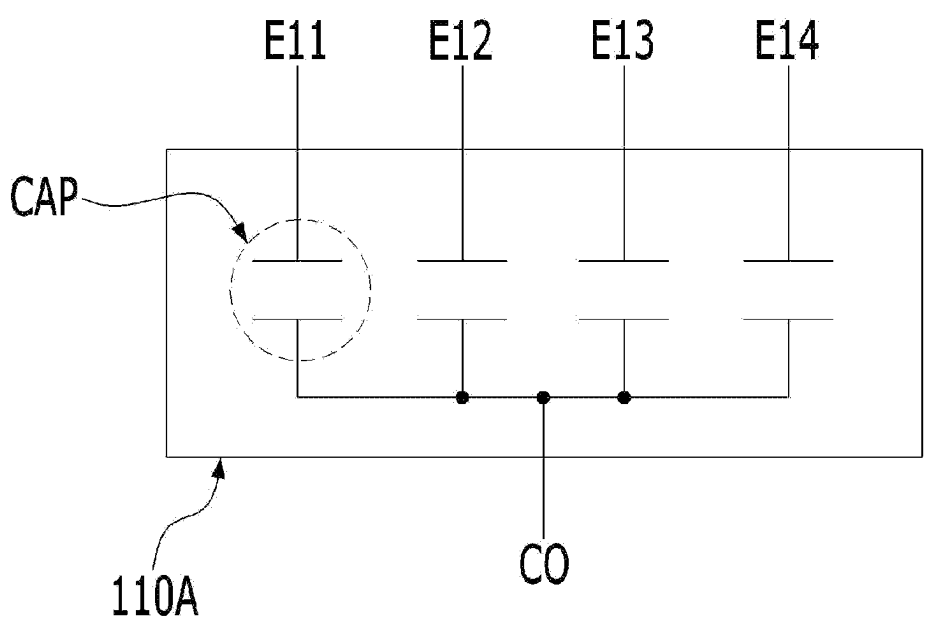
【FIG. 2】


110A
H4
E14
H5
CA
H6
H1
E11
E13
I
I'
H3
H7
H8
120A
120A1
120A2
E12
H2
z
x
y

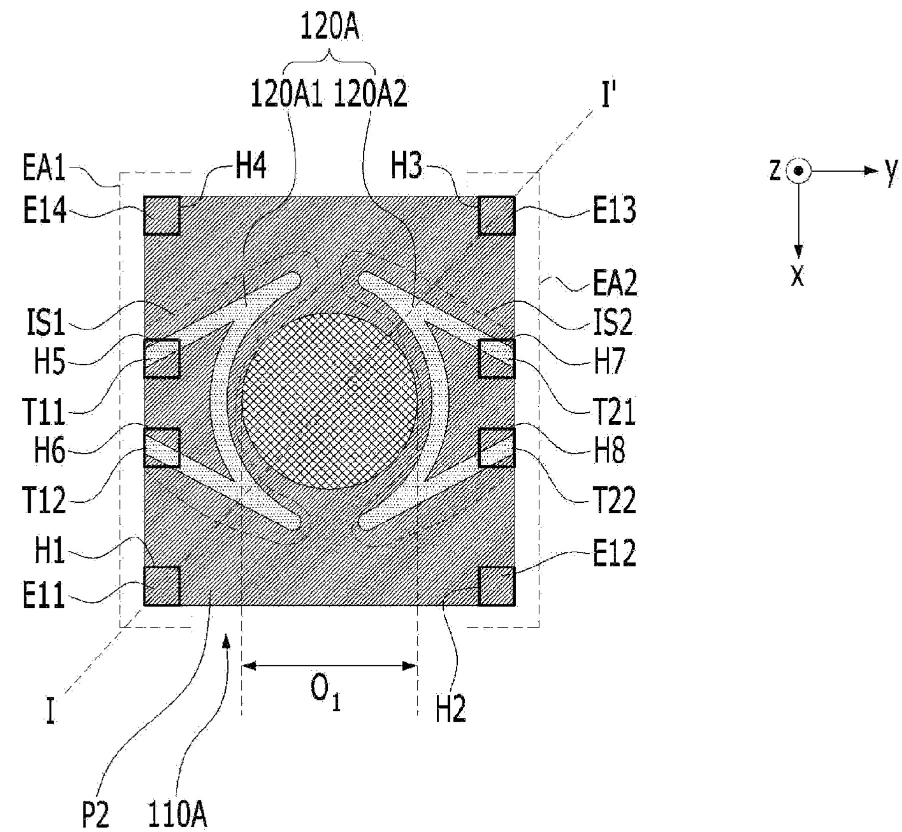
【FIG. 3】


IS1
P2
LQ2
CA
IS2
120A1
120A2
I
I'
132
O_1
132
E11
E13
SF1
i
i
P1
SF2
E2
O_2
134
134
B0
LQ1
116
P3
LX

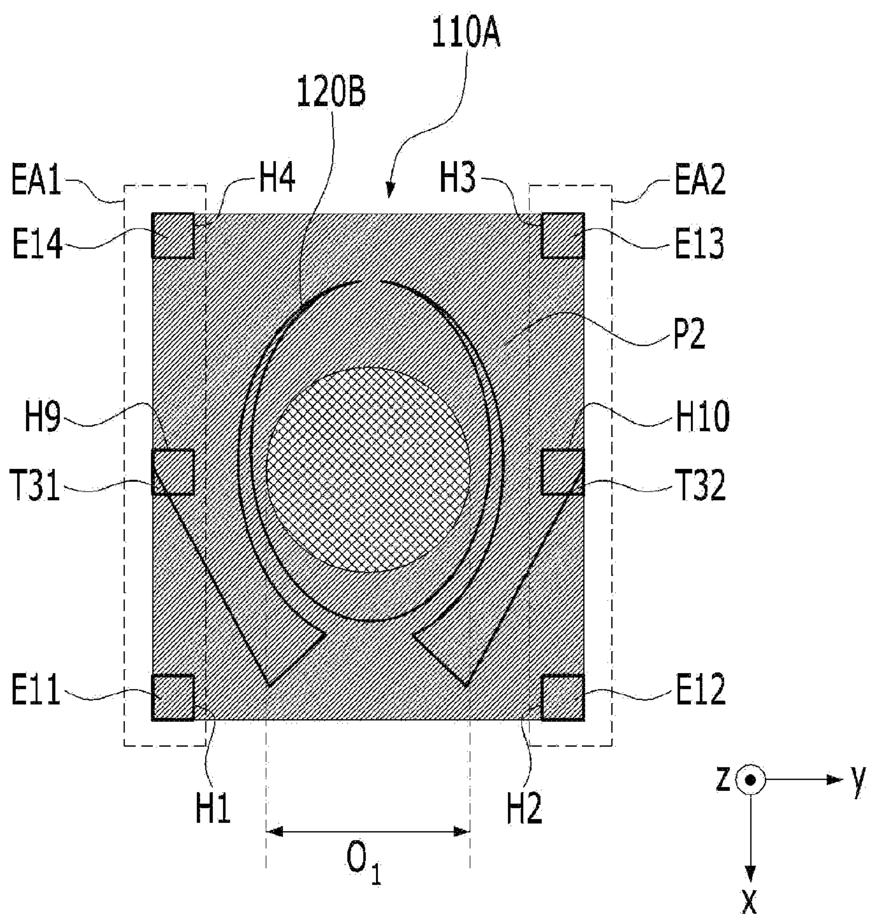
【FIG. 4】



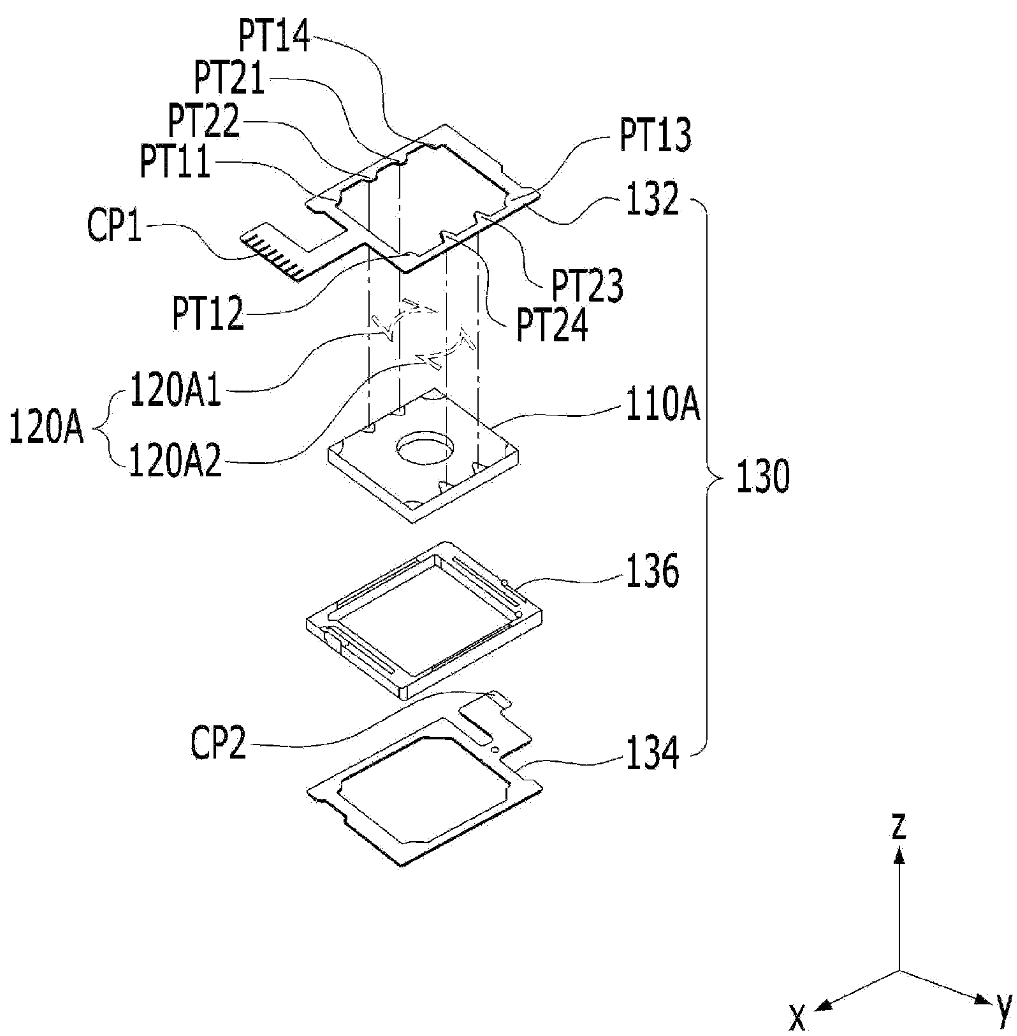
【FIG. 5】


120A
120A1 120A2
I'
EA1
H4
H3
E14
E13
EA2
IS1
IS2
H5
H7
T11
T21
H6
H8
T12
T22
H1
E12
E11
I
O1
H2
P2
110A
z
y
x

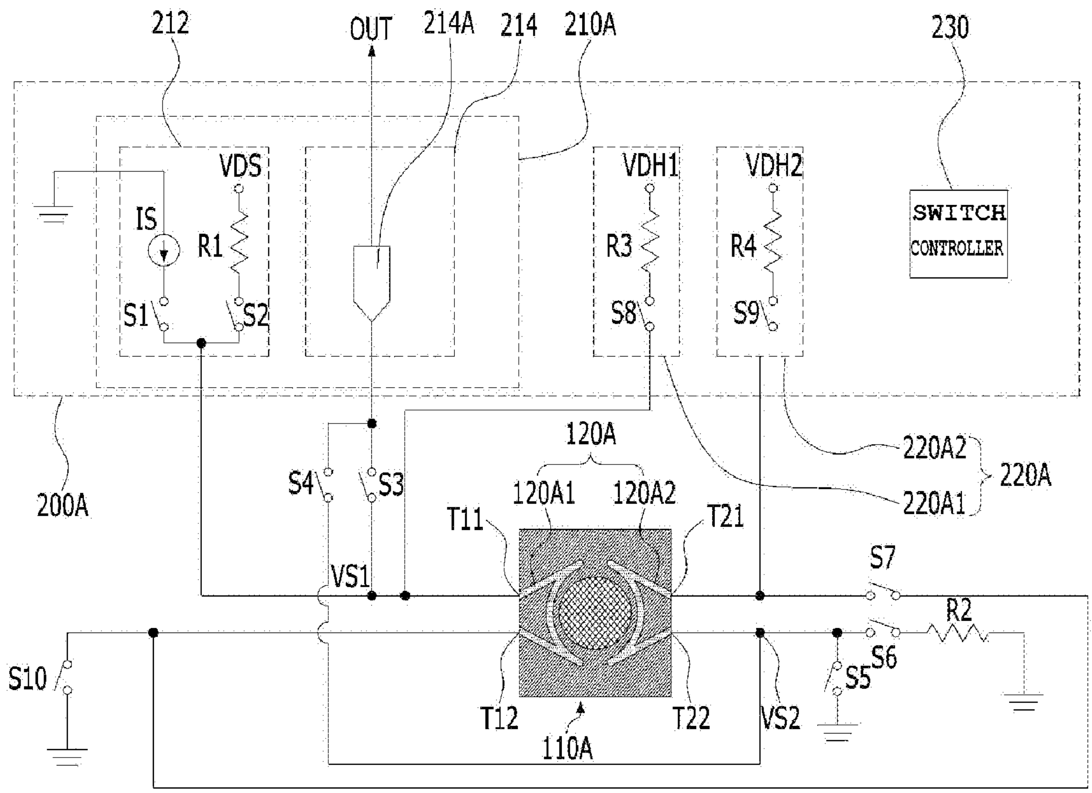
【FIG. 6】


110A
120B
EA1
H4
H3
EA2
E14
E13
P2
H9
H10
T31
T32
E11
E12
H1
H2
O_1
z
y
x

【FIG. 7】

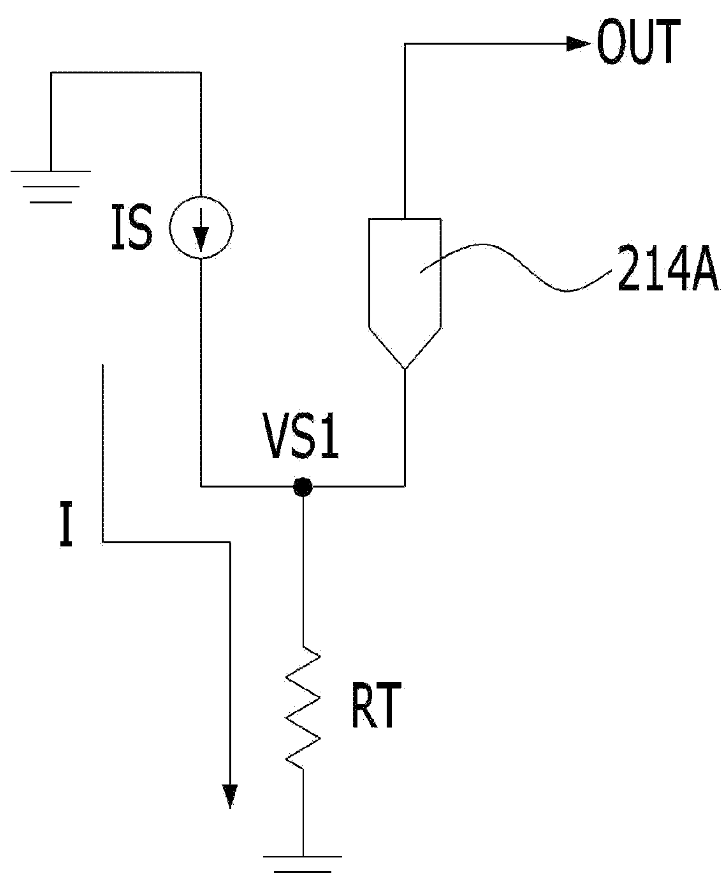

PT14
PT21
PT22
PT11
CP1
PT13
132
PT23
PT12
PT24
120A1
120A
120A2
110A
130
136
CP2
134
z
x
y

【FIG. 8】

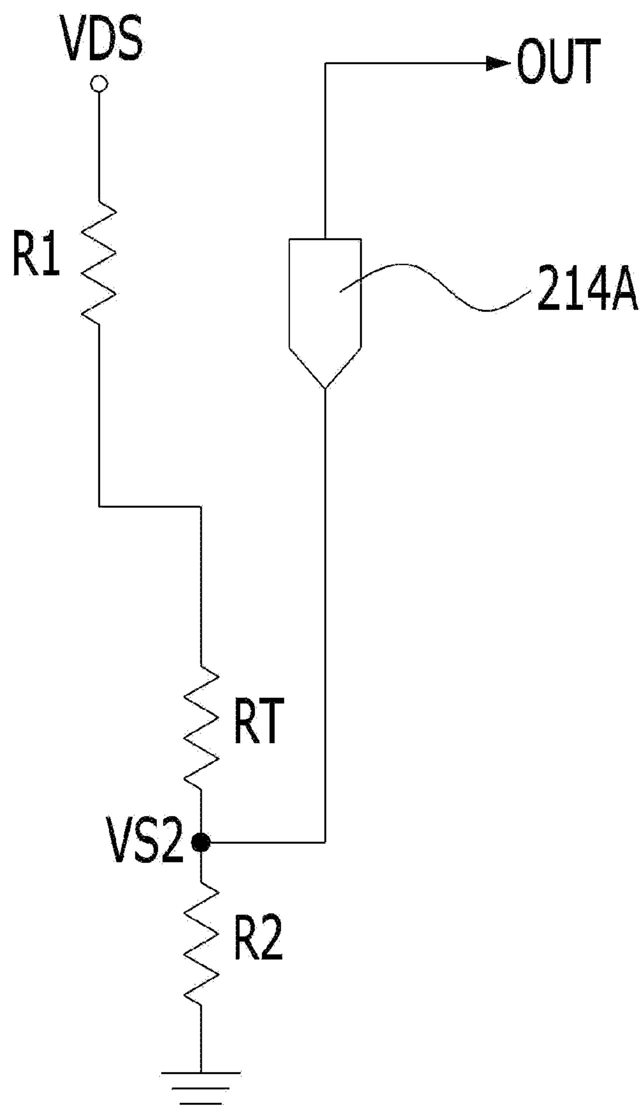


212
OUT
214A
214
210A
230
VDS
IS
R1
S1
S2
VDH1
R3
S8
VDH2
R4
S9
SWITCH CONTROLLER
200A
S4
S3
120A
120A1
120A2
T11
T21
220A2
220A1
220A
VS1
S7
R2
S6
S5
S10
T12
T22
VS2
110A

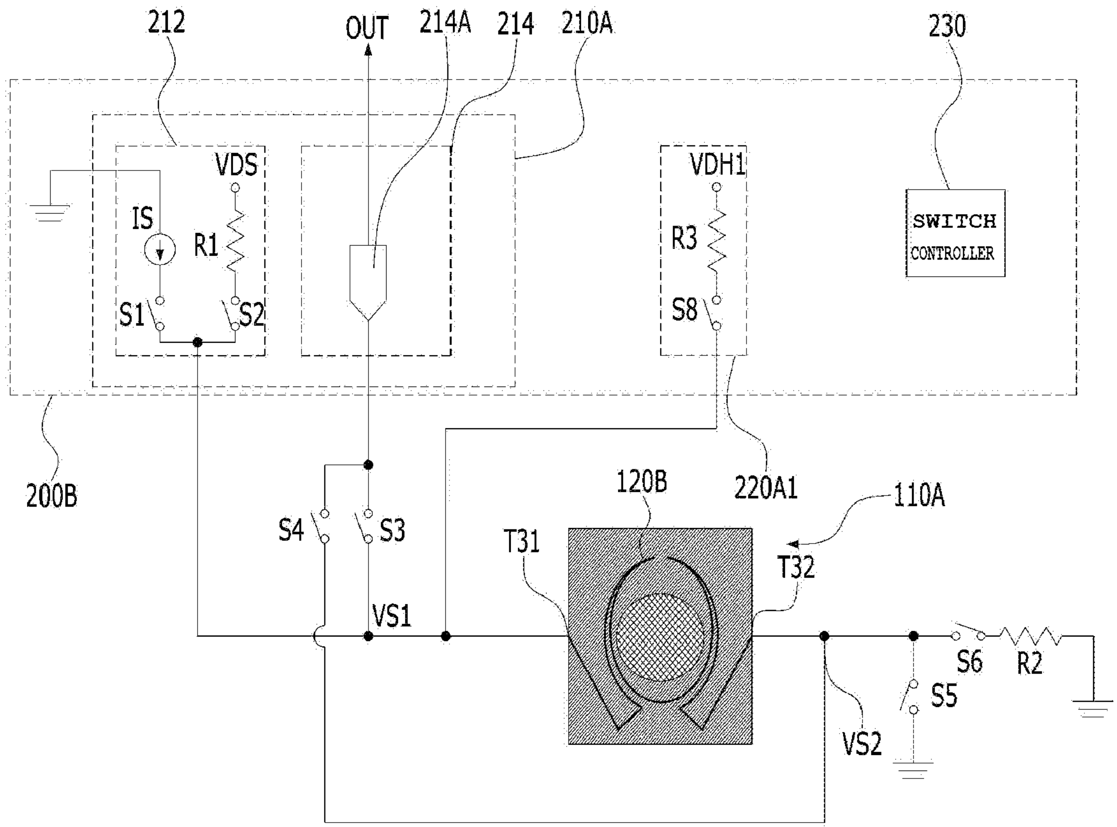
【FIG. 9】



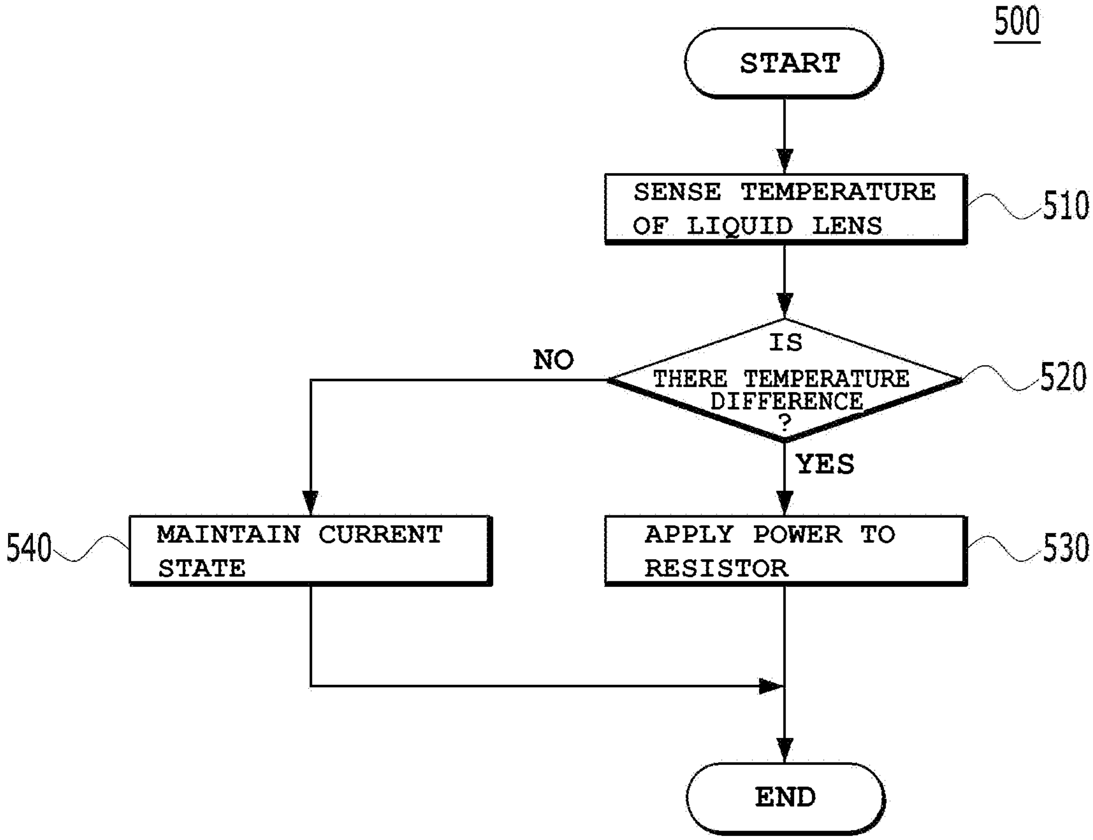
【FIG. 10】



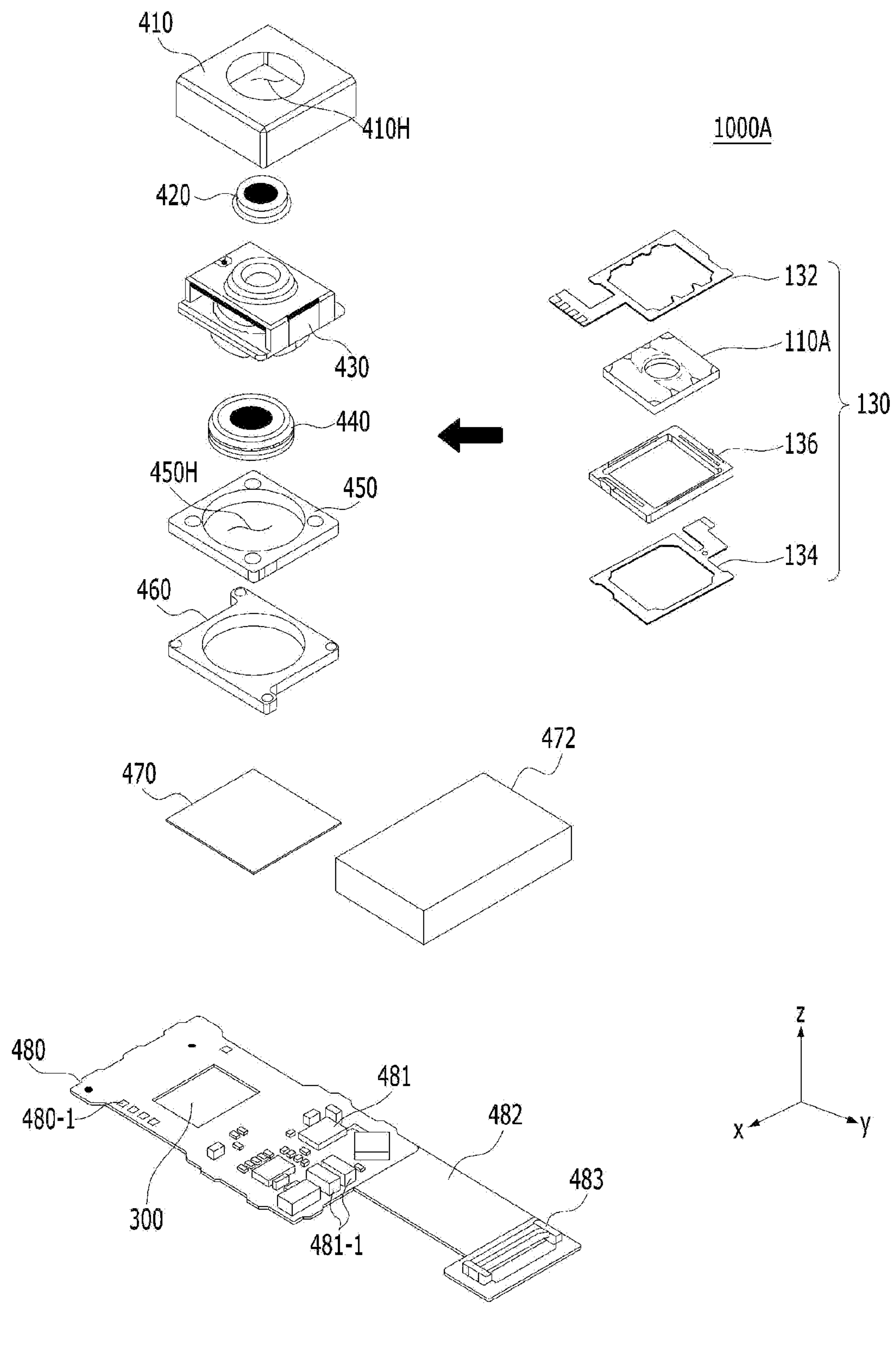
【FIG. 11】


212
OUT
214A
214
210A
230
VDS
IS
R1
S1
S2
VDH1
R3
S8
SWITCH
CONTROLLER
200B
120B
220A1
110A
S4
S3
T31
T32
VS1
S6
R2
S5
VS2

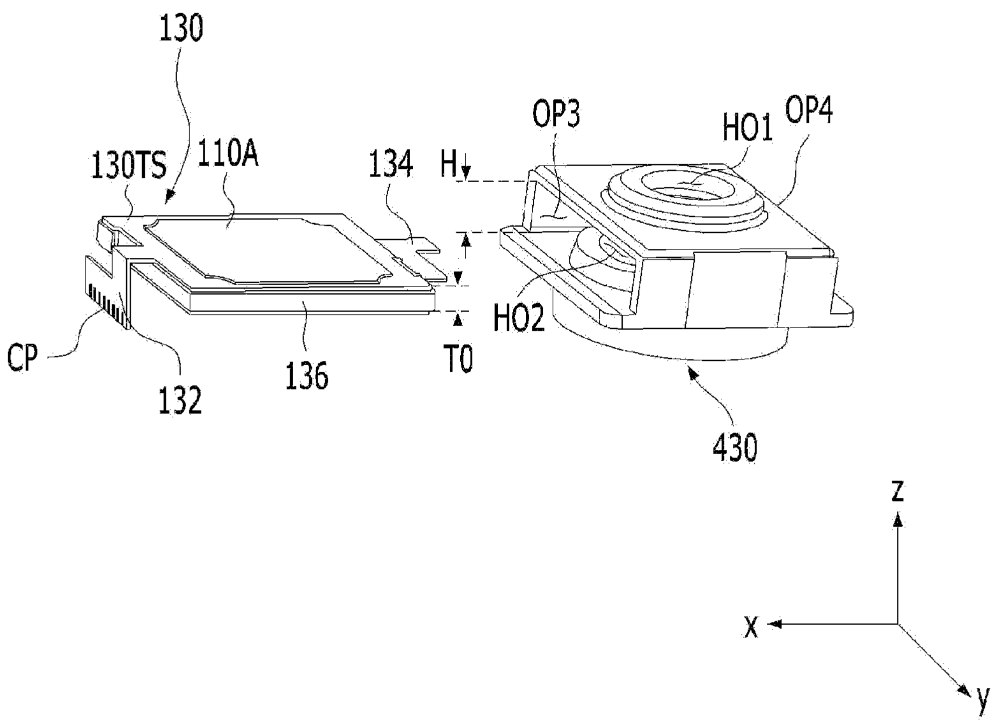
【FIG. 12】


500
START
SENSE TEMPERATURE OF LIQUID LENS
510
IS THERE TEMPERATURE DIFFERENCE ?
520
NO
YES
MAINTAIN CURRENT STATE
540
APPLY POWER TO RESISTOR
530
END

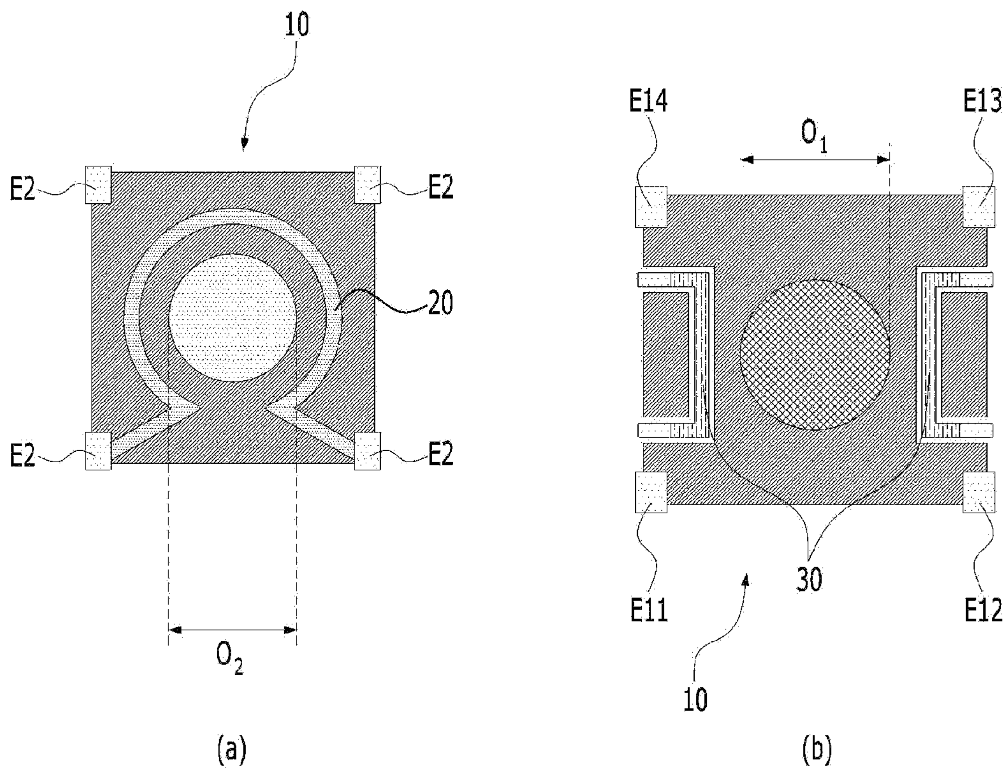
【FIG. 13】


410
410H
1000A
420
430
132
110A
130
440
136
450H
450
134
460
472
470
480
481
482
480-1
483
300
481-1
z
x
y

【FIG. 14】



【FIG. 15】



CAMERA MODULE INCLUDING LIQUID LENS, AND CONTROL METHOD THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

This application is the National Phase of PCT/KR2019/018180 filed on Dec. 20, 2019, which claims priority under 35 U.S.C. § 119(a) to Patent Application No. 10-2018-0167155 filed in the Republic of Korea on Dec. 21, 2018, all of which are hereby expressly incorporated by reference into the present application.

Technical Field

Embodiments relate to a camera module including a liquid lens and a control method thereof.

Background Art

People who use portable devices demand optical devices that have high resolution, are small, and have various photographing functions. For example, these various photographing functions may be at least one of an optical zoom-in/zoom-out function, an auto-focusing (AF) function, or a hand-tremor compensation or optical image stabilization (OIS) function.

In the conventional art, in order to implement the various photographing functions described above, a method of combining a plurality of lenses and directly moving the combined lenses is used. In the case in which the number of lenses is increased, however, the size of the optical device may increase.

The auto-focusing and hand-tremor compensation functions are performed by moving or tilting a plurality of lenses, which are secured to a lens holder and are aligned along an optical axis, in an optical-axis direction or a direction perpendicular to the optical axis. To this end, a separate lens-moving apparatus is required in order to move a lens assembly composed of a plurality of lenses. However, the lens-moving apparatus has high power consumption, and an additional cover glass needs to be provided separately from a camera module in order to protect the lens-moving apparatus, thus causing a problem in that the overall size of the conventional camera module is increased. In order to solve this, studies have been conducted on a liquid lens that performs auto-focusing and hand-tremor compensation functions by electrically adjusting the curvature and tilting of an interface between two types of liquids.

DISCLOSURE

Technical Problem

Embodiments provide a camera module including a liquid lens that is capable of controlling the temperature of the liquid lens and a control method thereof.

The objects to be accomplished by the embodiments are not limited to the above-mentioned objects, and other objects not mentioned herein will be clearly understood by those skilled in the art from the following description.

Technical Solution

A camera module according to an embodiment may include a liquid lens including a first plate and an individual electrode disposed on a first surface of the first plate, a

resistor disposed on the first surface of the first plate so as to be spaced apart from the individual electrode, a temperature sensor connected to the resistor and configured to sense the temperature of the liquid lens, and a heating controller connected to the resistor and configured to control the temperature of the liquid lens.

For example, the temperature sensor may include a sensing driver configured to supply a sensing signal to one end of the resistor, and the heating controller may include a heating driver configured to supply a heating signal to the one end of the resistor.

For example, the camera module may include a first switch disposed between the resistor and the sensing driver, a second switch disposed between the resistor and the heating driver, and a switch controller configured to control the first and second switches.

For example, the resistor may include an opposite end connected to a reference potential.

For example, the camera module may include a connection substrate connected to the individual electrode and the resistor, and the resistor may include first and second resistors, which are disposed so as to face each other, with the center of the liquid lens interposed therebetween.

For example, the temperature sensor may be connected to one end of the second resistor via one end of the first resistor and the opposite end of the first resistor.

For example, the heating controller may be connected to the one end of the first resistor and the one end of the second resistor.

For example, the opposite end of the first resistor may be connected to the reference potential, and the camera module may include a third switch, disposed between the opposite end of the first resistor and the reference potential, and a fourth switch, disposed between the opposite end of the first resistor and the one end of the second resistor.

According to another embodiment, a control method of a camera module may include sensing the temperature of the liquid lens, detecting a difference between the sensed temperature and a set target temperature of the liquid lens, and applying power to the resistor when there is a difference between the sensed temperature and the set target temperature of the liquid lens.

For example, the control method of the camera module may include maintaining a current state when there is no difference between the sensed temperature and the set target temperature of the liquid lens.

Advantageous Effects

According to a camera module including a liquid lens and a control method thereof according to the embodiments, a member corresponding to a thermistor and a member corresponding to a heater are disposed on a surface on which individual electrodes are disposed in the liquid lens, rather than being disposed on a surface on which a common electrode is disposed, whereby influence on the common electrode, which is a reference electrode, may be prevented, and thus operational stability may be secured.

In addition, in the case of a camera module according to the embodiments, since a resistor, which serves as a thermistor or a heater, is disposed on a first surface of a first plate, which is wider than a second surface of the first plate in the liquid lens, it is not necessary to increase the overall size of the liquid lens, making it possible to easily reduce the size of a bezel or eliminate a bezel.

In addition, in the case of a camera module according to the embodiments, since a resistor, which serves as a thermistor, is disposed on a first surface of a first plate, which is wider than a second surface of the first plate, the resistor is capable of being formed over a larger area than when the same is disposed on the second surface, whereby it is possible to more accurately sense the temperature of a liquid lens.

In addition, in the case of a camera module according to the embodiments, since a resistor is capable of serving both as a thermistor and as a heater, utilization of space inside the camera module is improved.

However, the effects achievable through the embodiments are not limited to the above-mentioned effects, and other effects not mentioned herein will be clearly understood by those skilled in the art from the following description.

DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic block diagram of a camera module according to an embodiment.

FIG. **2** is a perspective view of embodiments of the liquid lens and the resistor shown in FIG. **1**.

FIG. **3** is a cross-sectional view taken along line I-I' in FIG. **2**.

FIG. **4** shows an equivalent circuit of the liquid lens shown in FIG. **2**.

FIG. **5** is a view for explaining the planar shape of an embodiment of the resistor shown in FIG. **1**.

FIG. **6** is a view for explaining the planar shape of another embodiment of the resistor shown in FIG. **1**.

FIG. **7** is a perspective view of a liquid lens module according to an embodiment.

FIG. **8** is a diagram for explaining the operation of an embodiment of the camera module shown in FIG. **1**.

FIG. **9** shows an equivalent circuit of the camera module shown in FIG. **8** when a driving signal is supplied in the form of current.

FIG. **10** shows an equivalent circuit of the camera module shown in FIG. **8** when a driving signal is supplied in the form of voltage.

FIG. **11** is a diagram for explaining the operation of another embodiment of the camera module shown in FIG. **1**.

FIG. **12** is a flowchart for explaining a control method of the camera module according to an embodiment.

FIG. **13** is an exploded perspective view of an embodiment of the camera module shown in FIG. **1**.

FIG. **14** is a view for explaining the holder and the liquid lens module shown in FIG. **13**.

FIGS. **15**(*a*) and (*b*) are partial plan views of a camera module according to a comparative example.

BEST MODE

Hereinafter, exemplary embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

The technical spirit of the disclosure is not limited to the embodiments to be described, and may be implemented in various other forms, and one or more of the components may be selectively combined and substituted for use without exceeding the scope of the technical spirit of the disclosure.

In addition, terms (including technical and scientific terms) used in the embodiments of the disclosure, unless specifically defined and described explicitly, are to be interpreted as having meanings that may be generally understood by those having ordinary skill in the art to which the disclosure pertains, and meanings of terms that are commonly used, such as terms defined in a dictionary, should be interpreted in consideration of the context of the relevant technology.

Further, the terms used in the embodiments of the disclosure are for explaining the embodiments and are not intended to limit the disclosure. In this specification, the singular forms may also include plural forms unless otherwise specifically stated in a phrase, and in the case in which "at least one (or one or more) of A, B, or C" is stated, it may include one or more of all possible combinations of A, B, and C.

In addition, in describing the components of the embodiments of the disclosure, terms such as "first", "second", "A", "B", "(a)", and "(b)" can be used. Such terms are only for distinguishing one component from another component, and do not determine the nature, sequence or procedure etc. of the corresponding constituent elements.

In addition, when it is described that a component is "connected", "coupled" or "joined" to another component, the description may include not only being directly "connected", "coupled" or "joined" to the other component but also being "connected", "coupled" or "joined" by another component between the component and the other component.

In addition, in the case of being described as being formed or disposed "above (on)" or "below (under)" another component, the description includes not only the case where the two components are in direct contact with each other, but also the case where one or more other components are formed or disposed between the two components. In addition, when expressed as "above (on)" or "below (under)", it may refer to a downward direction as well as an upward direction with respect to one element.

A variable lens may be a variable focus lens. Further, a variable lens may be a lens that is adjustable in focus. A variable lens may be at least one of a liquid lens, a polymer lens, a liquid crystal lens, a VCM type, or an SMA type. A liquid lens may include a liquid lens including one liquid and a liquid lens including two liquids. A liquid lens including one liquid may change the focus by adjusting a membrane disposed at a position corresponding to the liquid, for using the example, by pressing the membrane electromagnetic force between a magnet and a coil. A liquid lens including two liquids may include a conductive liquid and a non-conductive liquid, and may adjust the interface formed between the conductive liquid and the non-conductive liquid using voltage applied to the liquid lens. A polymer lens may change the focus by controlling a polymer material using a driver such as a piezo actuator. A liquid crystal lens may change the focus by controlling a liquid crystal using electromagnetic force. A VCM type may change the focus by adjusting a solid lens or a lens assembly including a solid lens using electromagnetic force between a magnet and a coil. An SMA type may change the focus by controlling a solid lens or a lens assembly including a solid lens using a shape memory alloy.

Hereinafter, camera modules **1000** and **1000**A according to embodiments will be described as including a liquid lens as a variable lens, but the embodiments are not limited thereto.

Hereinafter, camera modules **1000** and **1000**A including a liquid lens according to embodiments will be described with reference to the accompanying drawings. Although the camera modules **1000** and **1000**A will be described using the Cartesian coordinate system (x-axis, y-axis, z-axis) for convenience of description, they may also be described using any of other coordinate systems. Although the x-axis, the y-axis, and the z-axis of the Cartesian coordinate system are perpendicular to each other, the embodiments are not limited thereto. That is, the x-axis, the y-axis, and the z-axis may intersect each other obliquely.

FIG. **1** is a schematic block diagram of a camera module **1000** according to an embodiment. Here, LX represents an optical axis.

The camera module **1000** shown in FIG. **1** may include a liquid lens **110**, a resistor **120**, a temperature sensor **210**, and a heating controller **220**.

Although it is illustrated in FIG. **1** that the resistor **120** belongs to a lens assembly **100**, the embodiments are not limited thereto. That is, unlike what is shown in FIG. **1**, the resistor **120** may be a constituent element of the camera module **1000**, rather than being a constituent element of the lens assembly **100**. Further, the embodiments are not limited to any specific configuration of the lens assembly **100** in which the liquid lens **110** is included. An example of the lens assembly **100** will be described later with reference to FIG. **13**.

FIG. **2** is a perspective view of embodiments **110**A and **120**A of the liquid lens **110** and the resistor **120** shown in FIG. **1**.

FIG. **3** is a cross-sectional view taken along line I-I' in FIG. **2**.

The liquid lens **110**A and the resistor **120**A shown in FIGS. **2** and **3**, which will be described below, are merely given as examples for helping understand the liquid lens **110** and the resistor **120** shown in FIG. **1**. That is, the liquid lens **110** and the resistor **120** shown in FIG. **1** may have various shapes different from those shown in FIGS. **2** and **3**.

The liquid lens **110**A shown in FIGS. **2** and **3** may include a plurality of different types of liquids LQ**1** and LQ**2**, first to third plates P**1**, P**2** and P**3**, first and second electrodes E**1** and E**2**, and an insulation layer **116**.

The liquid lens **110**A may include a cavity CA. The plurality of liquids LQ**1** and LQ**2** may be accommodated in the cavity CA, and may include a first liquid LQ**1**, which is conductive, and a second liquid (or an insulative liquid) LQ**2**, which is non-conductive. The first liquid LQ**1** and the second liquid LQ**2** may be immiscible with each other, and an interface BO may be formed at a contact portion between the first and second liquids LQ**1** and LQ**2**. In an example, the second liquid LQ**2** may be disposed on the first liquid LQ**1**, but the embodiments are not limited thereto.

In addition, in the cross-sectional shape of the liquid lens **110**A, the edges of the first and second liquids LQ**2** and LQ**1** may be thinner than the center portions thereof.

The first liquid LQ**1** may be a conductive material, and the second liquid LQ**2** may be an insulative material, which is non-conductive.

The inner side surface of the first plate P**1** may form a sidewall i of the cavity CA. The first plate P**1** may include upper and lower openings having a predetermined inclined surface. That is, the cavity CA may be a through-hole area formed in the first plate P**1**.

As shown in FIG. **3**, the area of the first opening in the direction in which light is introduced into the cavity CA may be smaller than the area of the second opening in the opposite direction. Alternatively, the liquid lens **110**A may be disposed such that the direction of inclination of the cavity CA is opposite what is illustrated. That is, unlike the illustration of FIG. **3**, the area of the second opening in the direction in which light is introduced into the cavity CA may be greater than the area of the first opening in the opposite direction. In addition, when the liquid lens **110**A is disposed such that the direction of inclination of the cavity CA is opposite what is illustrated, the arrangement of all or some of the components included in the liquid lens **110**A may be changed, or only the direction of inclination of the cavity CA may be changed and the arrangement of the remaining components may not be changed, according to the direction of inclination of the liquid lens **110**A.

The diameter of the wider opening among the first and second openings may be set in consideration of the field of view (FOV) required for the liquid lens **110**A or the role of the liquid lens **110**A in the camera module **1000**. According to the embodiment, the size (or the area or the width) of the second opening O_2 may be greater than the size (or the area or the width) of the first opening O_1. Here, the size of each of the first and second openings may be the cross-sectional area in the horizontal direction (e.g. the x-axis direction and the y-axis direction). For example, the size of each of the first and second openings may mean the radius when the opening has a circular cross-section, and may mean the diagonal length when the opening has a square cross-section.

Each of the first and second openings may take the form of a hole having a circular cross-section. The interface BO formed by the two liquids may be moved along the inclined surface of the cavity CA by a driving voltage.

The first liquid LQ**1** and the second liquid LQ**2** are charged, accommodated, or disposed in the cavity CA in the first plate P**1**. In addition, the cavity CA is a portion through which the light incident on the liquid lens **110**A passes. Thus, the first plate P**1** may be formed of a transparent material, or may include impurities so that light does not easily pass therethrough.

The multiple first electrodes E**1** may be disposed so as to be spaced apart from the second electrode E**2**, and may be respectively disposed on a first surface SF**1** (i.e. the upper surface), the side surface, and the lower surface of the first plate P**1**. The second electrode E**2** may be disposed on at least a portion of a second surface SF**2** (i.e. the lower surface) of the first plate P**1**, and may be in direct contact with the first liquid LQ**1**.

Referring to FIG. **3**, if the area of the top of the first plate P**1** and the area of the bottom thereof are the same as each other before the first and second openings are formed, since the first opening has a smaller area than the second area as described above, the area of the first surface SF**1** around the first opening in the first plate P**1** is larger than the area of the second surface SF**2** around the second opening in the first plate P**1**.

In addition, the first electrodes E**1** may be "n" electrodes (hereinafter referred to as "individual electrodes"), and the second electrode E**2** may be a single electrode (hereinafter referred to as a "common electrode"). Here, "n" is a positive integer of 2 or greater.

Hereinafter, the case in which n=4, i.e. in which the first electrodes E**1** include four individual electrodes E**11**, E**12**, E**13** and E**14**, will be described, but the embodiments are not limited thereto.

A portion of the second electrode E**2** disposed on the second surface SF**2** of the first plate P**1** may be exposed to the first liquid LQ**1**, which is conductive.

Each of the first and second electrodes E**1** and E**2** may be formed of a conductive material, e.g. metal.

In addition, the second plate P**2** may be disposed on one surface of each of the first electrodes E**1**. That is, the second plate P**2** may be disposed above the first surface SF**1** of the first plate P**1**. Specifically, the second plate P**2** may be disposed on the upper surfaces of the first electrodes E**1** and the cavity CA.

The third plate P3 may be disposed on one surface of the second electrode E2. That is, the third plate P3 may be disposed below the second surface SF2 of the first plate P1. Specifically, the third plate P3 may be disposed under the lower surface of the second electrode E2 and the cavity CA.

The second plate P2 and the third plate P3 may be disposed so as to face each other, with the first plate P1 interposed therebetween. In addition, at least one of the second plate P2 or the third plate P3 may be omitted.

At least one of the second plate P2 or the third plate P3 may have a rectangular planar shape. The third plate P3 may be brought into contact with and bonded to the first plate P1 on a bonding area around the edge thereof.

Each of the second and third plates P2 and P3 may be an area through which light passes, and may be formed of a light-transmissive material. For example, each of the second and third plates P2 and P3 may be formed of glass, and, for convenience of processing, may be formed of the same material.

The second plate P2 may be configured to allow the light incident on the liquid lens 110A to travel into the cavity CA in the first plate P1.

The third plate P3 may be configured to allow the light that has passed through the cavity CA in the first plate P1 to be emitted from the liquid lens 110A. The third plate P3 may be in direct contact with the first liquid LQ1.

According to the embodiment, the third plate P3 may have a diameter greater than the diameter of the wider opening among the first and second openings in the first plate P1. In addition, the third plate P3 may include a peripheral area spaced apart from the first plate P1.

The insulation layer 116 may be disposed so as to cover a portion of the lower surface of the second plate P2 in the upper area of the cavity CA. That is, the insulation layer 116 may be disposed between the second liquid LQ2 and the second plate P2.

In addition, the insulation layer 116 may be disposed so as to cover portions of the first electrodes E1 that form the sidewall of the cavity CA. In addition, the insulation layer 116 may be disposed on the lower surface of the first plate P1 so as to cover portions of the first electrodes E1, a portion of the first plate P1, and a portion of the second electrode E2. Thus, contact between the first electrode E1 and the first liquid LQ1 and contact between the first electrode E1 and the second liquid LQ2 may be prevented by the insulation layer 116. The insulation layer 116 may cover one electrode among the first and second electrodes E1 and E2 (e.g. the first electrodes E1), and may expose a portion of the other electrode (e.g. the second electrode E2) so that electrical energy is applied to the first liquid LQ1, which is conductive.

FIG. 4 shows an equivalent circuit of the liquid lens 110A shown in FIG. 2.

The operation of the liquid lens 110A will be described below with reference to FIGS. 2 and 4.

The liquid lens 110A, the interface BO of which is adjusted in shape in response to a driving voltage, may receive the driving voltage via multiple first electrodes E1: E11, E12, E13 and E14, which are disposed in four different directions at the same angular interval, and the second electrode E2: CO. When the driving voltage is applied via any one of the multiple first electrodes E1: E11, E12, E13 and E14 and the second electrode E2: CO, the shape of the interface BO between the first liquid LQ1 and the second liquid LQ2, which are disposed in the cavity CA, may be deformed. The degree of deformation and the shape of the interface BO between the first liquid LQ1 and the second liquid LQ2 may be controlled by the control circuit 200 in order to implement at least one of the AF function or the OIS function. That is, the control circuit 200 may generate a driving voltage to control the liquid lens 110A.

In addition, referring to FIG. 4, the liquid lens 110A may be conceptually explained as a plurality of capacitors CAP, in which one side of the liquid lens 110A receives voltages from the first electrodes E1: E11, E12, E13 and E14 and the other side of the liquid lens 110A is connected to the second electrode E2: CO to receive a voltage therefrom.

Meanwhile, in order to explain the concept of the camera module 1000 according to the embodiment, the resistor 120 is illustrated in FIG. 1 as being spaced apart from the liquid lens 110. However, the resistor 120 may be disposed inside the liquid lens 110. That is, according to the embodiment, the resistor 120 shown in FIG. 1 may be spaced apart from the first electrodes E1: E11, E12, E13 and E14, which are individual electrodes, as shown in FIG. 2, and may be disposed on the first surface SF1 of the first plate P1, on which the first electrodes E1: E11, E12, E13 and E14, which are individual electrodes, are disposed, as shown in FIG. 3. Alternatively, the resistor may be disposed on the first surface SF1, which is the wider surface among the first surface SF1 and the second surface SF2 of the first plate P1.

FIGS. 5 and 6 are views for explaining the planar shapes of various embodiments 120A and 120B of the resistor 120 shown in FIG. 1.

FIG. 3 corresponds to a cross-sectional view taken along line I-I' in FIG. 5. The resistor 120 shown in each of FIGS. 3, 5 and 6 is embedded in the second plate P2, as shown in FIG. 3, and thus is not visible. However, for better understanding, the resistors 120A and 120B are shown in FIGS. 3, 5 and 6.

According to an embodiment, the resistor 120 shown in FIG. 1 may include first and second resistors 120A1 and 120A2, which are spaced apart from each other and are disposed on the same surface of the first plate P1, i.e. the first surface SF1, as shown in FIGS. 2 and 5.

In addition, as shown in FIG. 5, the first resistor 120A1 and the second resistor 120A2 may have planar shapes, which are symmetric to each other with respect to a surface that is perpendicular to the y-axis direction, is parallel to the x-axis and the z-axis, and passes through the center of the liquid lens 110A, but the embodiments are not limited thereto.

In addition, the first and second resistors 120A1 and 120A2 may be disposed so as to face each other, with the center of the liquid lens 110A interposed therebetween.

According to another embodiment, the resistor 120 shown in FIG. 1 may include a single resistor 120B, as shown in FIG. 6. In addition, as shown in FIG. 6, the resistor 120B may have a planar shape, which is symmetric with respect to a surface that is perpendicular to the y-axis direction, is parallel to the x-axis and the z-axis, and passes through the center of the liquid lens 110A, but the embodiments are not limited thereto.

FIGS. 2, 5 and 6 show exemplary planar shapes of the resistors 120A and 120B, but the embodiments are not limited thereto, and may provide various other planar shapes thereof.

Hereinafter, the resistors 120A and 120B shown in FIGS. 5 and 6 will be described in detail.

As shown in FIG. 3, the resistor 120A may be disposed between the first surface SF1 of the first plate P1 and the second plate P2. Therefore, although the resistor 120A is not visible from the outside, the same is indicated by the dotted lines in FIG. 2 in order to promote an understanding of the embodiment. Further, although not shown, the resistor **120**B shown in FIG. **6** may also be disposed so as to be embedded in the second plate P**2**, like the resistor **120**A.

Further, referring to FIG. **3**, the first and second resistors **120**A**1** and **120**A**2** may be disposed on the first plate P**1**.

For better understanding, insulation layers IS**1** and IS**2**, which are not visible from the outside, are illustrated in FIG. **5**. Although the insulation layers IS**1** and IS**2** are illustrated in FIG. **5** as being disposed around the first and second resistors **120**A**1** and **120**A**2**, the embodiments are not limited to any specific planar shape of the insulation layers IS**1** and IS**2**. Further, although not shown, the insulation layers IS**1** and IS**2** may also have planar shapes for electrically separating the four first electrodes E**11**, E**12**, E**13** and E**14** from each other.

Current may be supplied to the resistors **120**A and **120**B in order to sense the temperature of the liquid lens **110**A or to heat the liquid lens **110**A, which will be described later with reference to FIGS. **8** and **11**. In this case, when the resistors **120**A and **120**B are directly disposed on the first electrodes E**1** without interposing the insulation layers IS**1** and IS**2** between the resistors **120**A and **120**B and the first electrodes E**1**, the first electrodes E**1** and the resistors **120**A and **120**B may be short-circuited. In order to prevent this, the insulation layers IS**1** and IS**2** are disposed between the first electrodes E**1** and the resistors **120**A and **120**B in order to electrically separate these components E**1**, **120**A and **120**B from each other, thereby preventing these components E**1**, **120**A and **120**B from being short-circuited. An air layer, a glass layer, which is generated due to fusion of the first plate and the second plate, or another insulation member may be disposed as the insulation layers IS**1** and IS**2**, or the insulation layers IS**1** and IS**2** may be formed of the same material as that of the insulation layer **116** shown in FIG. **3**.

For example, when receiving a sensing signal from the temperature sensor **210**, the resistors **120**A and **120**B may sense the temperature of the liquid lens **110**A, and when receiving a heating signal from the heating controller **220**, the resistors **120**A and **120**B may be implemented as resistors capable of heating the liquid lens **110**A. That is, when receiving a sensing signal from the temperature sensor **210**, the resistors **120**A and **120**B may serve as a thermistor. A thermistor is a semiconductor that is sensitive to heat and has a resistance value that changes with changes in temperature. Alternatively, when receiving a heating signal from the heating controller **220**, the resistors **120**A and **120**B may serve as heating resistors that generate heat when current flows therethrough.

The embodiments are not limited to any specific type of resistors **120**A and **120**B. That is, any element can be employed as the resistors **120**A and **120**B, so long as it is capable of generating heat when receiving a current and the characteristic value (e.g. a resistance value) thereof changes with changes in the temperature of the liquid lens **110**A.

Meanwhile, referring again to FIG. **1**, the temperature sensor **210** may be connected to the resistor **120** to sense information on the temperature of the liquid lens **110** (or the temperature of the resistor **120**), and may output the sensed temperature information through an output terminal OUT. The temperature sensor **210** may be included in the control circuit **200**, but the embodiments are not limited to any specific configuration of the control circuit **200** in which the temperature sensor **210** is included. For example, the temperature sensor **210** may be disposed on a connection substrate, which electrically connects the control circuit **200** to the liquid lens.

In addition, the heating controller **220** may be connected to the resistor **120** to control the heating operation of the resistor **120**. In addition, the heating controller **220** may control the amount of heat emitted from the resistor **120** as well as the heating operation of the resistor **120**.

The control circuit **200**, which is capable of performing the functions of the temperature sensor **210** and the heating controller **220**, may serve to supply a driving voltage (or an operation voltage) to the liquid lens **110**. The control circuit **200** and the image sensor **300** may be mounted on a single main board, for example, a printed circuit board (PCB), but this is merely given by way of example, and the embodiments are not limited thereto. That is, the temperature sensor **210** and the heating controller **220** may be disposed on the main board. The control circuit **200** may correspond to the main board **480** shown in FIG. **13**, to be described later.

The image sensor **300** may perform a function of converting the light that has passed through the liquid lens **110** of the lens assembly **100** into image data. More specifically, the image sensor **300** may generate image data by converting light into analog signals via a pixel array including a plurality of pixels and synthesizing digital signals corresponding to the analog signals.

When the camera module **1000** according to the embodiment is applied to an optical device (or an optical instrument), the configuration of the control circuit **200** may be designed in different ways depending on the specifications of the optical device. In particular, the control circuit **200** may be implemented as a single chip so as to reduce the magnitude of the driving voltage that is applied to the lens assembly **100**. Thereby, the size of an optical device mounted in a portable device may be further reduced.

The liquid lens **110**: **110**A and the resistor **120**: **120**A and **120**B shown in FIGS. **1** to **3**, **5** and **6** may be modularized.

Hereinafter, the modularized liquid lens **110** or **110**A will be referred to as a "liquid lens module", and a liquid lens module **130** will be described below with reference to FIG. **7**. Hereinafter, the liquid lens module **130** will be described as including the resistor **120**A shown in FIG. **5**, but the following description may also apply to the case in which the liquid lens module **130** includes the resistor **120**B shown in FIG. **6**, unless otherwise noted. That is, the resistor **120**A shown in FIG. **7** may be replaced with the resistor **120**B shown in FIG. **6**. That is, the liquid lens module **130** may include the resistor **120**B shown in FIG. **6**, rather than the resistor **120**A shown in FIG. **5**.

FIG. **7** is a perspective view of the liquid lens module **130** according to an embodiment.

Although the resistor **120**A is embedded in the liquid lens **110**A, the same is illustrated in FIG. **7** as being located outside the liquid lens **110**A in order to help understand the connection relationships between a first connection substrate **132** and the resistor **120**A.

FIG. **7** is a plan view showing the state before a first connection substrate **132** and a second connection substrate **134** are bent in the −z-axis direction.

The liquid lens module **130** may include a first connection substrate **132**, a liquid lens **110**A, a resistor **120**A, and a second connection substrate **134**. The liquid lens **110**A and the resistor **120** according to the embodiment are not limited to any specific configuration of the liquid lens module **130** to be described below.

Since the liquid lens **110**A and the resistor **120**A shown in FIG. **7** respectively correspond to the liquid lens **110**A and the resistor **120**A shown in FIGS. **2**, **3** and **5**, the same reference numerals are used, and a duplicate description thereof is omitted.

The first connection substrate **132** may electrically connect the multiple first electrodes E**1**: E**11**, E**12**, E**13** and E**14** included in the liquid lens **110**A to the main board including the control circuit **200**, and may be disposed on the liquid lens **110**A. In addition, the first connection substrate **132** may electrically connect the resistor **120**A to the main board.

The first connection substrate **132** and the resistor **120**A may be electrically connected to each other in any of various forms. An example thereof will be described below with reference to FIGS. **2**, **3** and **5** to **7**, but the embodiments are not limited thereto.

Referring to FIGS. **2**, **3** and **5** to **7**, in order to allow the first electrodes E**1**: E**11**, E**12**, E**13** and E**14** to be electrically connected to the first connection substrate **132**, the second plate P**2** exposes portions of the first electrodes E**1**. Similarly, the second plate P**2** may expose end portions of the resistor **120**: **120**A and **120**B.

For example, referring to FIGS. **2**, **5** and **6**, in order to electrically connect the four first electrodes E**1**: E**11**, E**12**, E**13** and E**14** to the first connection substrate **132**, the second plate P**2** may include therein first to fourth recesses H**1** to H**4**. The first recess H**1** exposes one E**11** of the first electrodes E**1**, the second recess H**2** exposes another one E**12** of the first electrodes E**1**, the third recess H**3** exposes still another one E**13** of the first electrodes E**1**, and the fourth recess H**4** exposes still another one H**14** of the first electrodes E**1**.

In addition, in the case in which the resistor **120** shown in FIG. **1** is implemented as shown in FIG. **5**, the second plate P**2** of the liquid lens **110**A shown in FIG. **2** may further include therein fifth to eighth recesses H**5** to H**8**. Referring to FIGS. **2** and **5**, the fifth recess H**1** exposes one end T**11** of the first resistor **120**A1, the sixth recess H**6** exposes the opposite end T**12** of the first resistor **120**A1, the seventh recess H**7** exposes one end T**21** of the second resistor **120**A2, and the eighth recess H**8** exposes the opposite end T**22** of the second resistor **120**A2.

FIG. **2** shows the state after the first to eighth recesses H**1** to H**8** are formed in the second plate P**2**, and FIG. **5** shows the state before the first to eighth recesses H**1** to H**8** are formed in the second plate P**2**.

Alternatively, in the case in which the resistor **120** shown in FIG. **1** is implemented as shown in FIG. **6**, the second plate P**2** of the liquid lens **110**A shown in FIG. **2** may include therein first to fourth, ninth and tenth recesses H**1** to H**4**, H**9** and H**10**. Referring to FIG. **6**, the ninth recess H**9** exposes one end T**31** of the resistor **120**B, and the tenth recess H**10** exposes the opposite end T**32** of the resistor **120**B. FIG. **6** shows the state before the first to fourth, ninth and tenth recesses H**1** to H**4**, H**9** and H**10** are formed in the second plate P**2**.

Referring to FIGS. **5** and **6**, in the liquid lens **110**A, the first surface SF**1** of the first plate P**1** may include first and second edge areas EA**1** and EA**2**. The first edge area EA**1** may be an area that faces the second edge area EA**2**, with the center of the liquid lens **110**A interposed therebetween. That is, the second edge area EA**2** may be an area that is opposite the first edge area EA**1**.

Referring to FIG. **5**, one end T**11** and the opposite end T**12** of the first resistor **120**A1 and some E**11** and E**14** of the first electrodes E**1** may be disposed in the first edge area EA**1**, and one end T**21** and the opposite end T**22** of the second resistor **120**A2 and some E**12** and E**13** of the first electrodes E**1** may be disposed in the second edge area EA**2**.

Referring again to FIG. **7**, the first connection substrate **132** may include first protruding portions P**11** to P**14**, which protrude from the respective four inner corners thereof toward the liquid lens **110**A and are respectively electrically or physically connected to the four first electrodes E**11**, E**12**, E**13** and E**14**, which are respectively exposed through the first to fourth recesses H**1** to H**4**. Among the first protruding portions, the 1-1st protruding portion P**11** may be electrically or physically connected to the 1-1st electrode E**11**, which is exposed through the first recess H**1**, the 1-2nd protruding portion P**12** may be electrically or physically connected to the 1-2nd electrode E**12**, which is exposed through the second recess H**2**, the 1-3rd protruding portion P**13** may be electrically or physically connected to the 1-3rd electrode E**13**, which is exposed through the third recess H**3**, and the 1-4th protruding portion P**14** may be electrically or physically connected to the 1-4th electrode E**14**, which is exposed through the fourth recess H**4**.

In addition, the first connection substrate **132** may include second protruding portions P**21** to P**24**, which protrude from the inner edge surfaces between the inner corners thereof toward the liquid lens **110**A. Among the second protruding portions, the 2-1st protruding portion P**21** is electrically or physically connected to one end T**11** of the first resistor **120**A1, which is exposed through the fifth recess H**5**. The 2-2nd protruding portion P**22** is electrically or physically connected to the opposite end T**12** of the first resistor **120**A1, which is exposed through the sixth recess H**6**. The 2-3rd protruding portion P**23** is electrically or physically connected to one end T**21** of the second resistor **120**A2, which is exposed through the seventh recess H7. The 2-4th protruding portion P**24** may be electrically or physically connected to the opposite end T**22** of the second resistor **120**A2, which is exposed through the eighth recess H**8**.

However, in the case in which the resistor **120** is implemented as shown in FIG. **6**, although not shown, the first connection substrate **132** may include third protruding portions P**31** and P**32**. Among the third protruding portions, the 3-1st protruding portion P**31** may be electrically connected to one end T**31** of the resistor **120**B, which is exposed through the ninth recess H9, and the 3-2nd protruding portion P**32** may be electrically connected to the opposite end T**32** of the resistor **120**B, which is exposed through the tenth recess H**10**.

Referring to FIG. **7**, the first connection substrate **132** may include a connection pad CP**1**, which is electrically connected to the four first protruding portions PT**11** to P**14** and the four second protruding portions P**21** to P**24**. The connection pad CP**1** of the first connection substrate **132** may be electrically connected to an electrode pad (not shown), which is formed on the main board (e.g. **480** shown in FIG. **13**) of the control circuit **200**. To this end, after the first connection substrate **132** is bent in the −z-axis direction toward the main board, the connection pad CP**1** and the electrode pad may be electrically connected to each other via conductive epoxy.

If the first connection substrate **132** further includes the four second protruding portions P**25** to P**28** described above, the connection pad CP**1** may be electrically connected to the four second protruding portions P**25** to P**28**. In addition, if the first connection substrate **132** further includes the two third protruding portions P**31** and P**32** described above, the connection pad CP**1** may be electrically connected to the two third protruding portions P**31** and P**32**.

In addition, the first connection substrate **132** may be implemented as a flexible printed circuit board (FPCB).

The second connection substrate **134** may electrically connect the second electrode E**2** included in the liquid lens **110**A to the main board (e.g. **480** shown in FIG. **13**), and may be disposed below the liquid lens **110**A. The second connection substrate **134** may be implemented as an FPCB or a single metal substrate (a conductive metal plate).

The second connection substrate **134** may be electrically connected to the electrode pad, which is formed on the main board, via a connection pad CP**2**, which is electrically connected to the second electrode E**2**. To this end, the second connection substrate **134** may be bent in the −z-axis direction toward the main board **200**.

The liquid lens module **130** according to the embodiment may further include a spacer **136**.

The spacer **136** may have a ring shape, and may be disposed between the first connection substrate **132** and the second connection substrate **134** so as to surround the side surface of the liquid lens **110**A, thereby protecting the liquid lens **110**A from external impacts. To this end, the spacer **136** may have a shape that allows the liquid lens **110**A to be mounted in, seated in, in contact with, fixed to, provisionally fixed to, supported by, coupled to, or disposed in the spacer.

Hereinafter, an example in which the temperature sensor **210** shown in FIG. **1** senses the temperature of the liquid lens **110** using the resistor **120** or the heating controller **220** heats the liquid lens **110** using the resistor **120** will be described with reference to the accompanying drawings.

First, an embodiment in which the resistor **120**A shown in FIG. **5** is used to sense the temperature of the liquid lens **110**A or to heat the liquid lens **110**A will be described below with reference to FIGS. **8** to **10**.

FIG. **8** is a diagram for explaining the operation of an embodiment of the camera module **1000** shown in FIG. **1**.

The temperature sensor **210**A and the heating controller **220**A shown in FIG. **8** respectively correspond to embodiments of the temperature sensor **210** and the heating controller **220** shown in FIG. **1**.

The electrical connection relationships in the case in which the first and second resistors **120A1** and **120A2** are used in order to sense the temperature of the liquid lens **110**A will be described below.

The temperature sensor **210**A may be connected to one end T**11** of the first resistor **120A1**. To this end, one end T**11** of the first resistor **120A1** may be electrically connected to the temperature sensor **210**A, which is disposed on the main board (e.g. **480** shown in FIG. **13**), via the first connection substrate **132**. Alternatively, as will be described later, the temperature sensor **210**A may be connected to the opposite end T**22** of the second resistor **120A2** as well as one end T**11** of the first resistor **120A1**. To this end, one end T**11** of the first resistor **120A1** and the opposite end T**22** of the second resistor **120A2** may be electrically connected to the temperature sensor **210**A, which is disposed on the main board, via the first connection substrate **132**.

In addition, the opposite end T**12** of the first resistor **120A1** may be connected to one end T**21** of the second resistor **120A2**. To this end, the opposite end T**12** of the first resistor **120A1** may be connected to one end T**21** of the second resistor **120A2** via the first connection substrate **132** or via the first connection substrate **132** and the main board. Accordingly, the temperature sensor **210**A may be connected to one end T**21** of the second resistor **120A2** via one end T**11** and the opposite end T**12** of the first resistor **120A1**.

The opposite end T**22** of the second resistor **120A2** may be connected to a reference potential (or ground) or a resistor R**2**. To this end, the opposite end T**22** of the second resistor **120A2** may be connected to the reference potential or the resistor R**2** via the first connection substrate **132** or via the first connection substrate **132** and the main board.

The electrical connection relationships in the case in which the first and second resistors **120A1** and **120A2** are used in order to heat the liquid lens **110**A will be described below.

In order to control the generation of heat by the resistor **120**, the heating controller **220** shown in FIG. **1** serves to supply a heating signal to one end of the resistor **120**. In the embodiment, when the resistor **120** shown in FIG. **1** includes the first and second resistors **120A1** and **120A2**, as shown in FIGS. **5** and **8**, the heating controller **220**A may be configured as a first heating driver **220**A, which is one heating driver, or may include first and second heating drivers **220A1** and **220A2**.

The first heating driver **220A1** may supply a first heating signal to one end T**11** of the first resistor **120A1**, and the second heating driver **220A2** may supply a second heating signal to one end T**21** of the second resistor **120A2**. To this end, the first heating driver **220A1** may be connected to one end T**11** of the first resistor **120A1**, and the second heating driver **220A2** may be connected to one end T**21** of the second resistor **120A2**. For example, one end T**11** of the first resistor **120A1** and one end T**21** of the second resistor **120A2** may be respectively electrically connected to the first and second heating drivers **220A1** and **220A2**, which are disposed on the main board (e.g. **480** shown in FIG. **13**), via the first connection substrate **132**.

In addition, the opposite ends T**12** and T**22** of the first and second resistors **120A1** and **120A2** may be connected to the reference potential (e.g. ground). To this end, the opposite ends T**12** and T**22** of the first and second resistors **120A1** and **120A2** may be connected to the reference potential via the first connection substrate **132** and the main board.

According to the embodiment, the temperature sensor **210**A may include a sensing driver **212** and a temperature information measurer **214**.

The sensing driver **212** serves to supply a driving signal (or a sensing signal) to the first and second resistors **120**A. For example, the sensing driver **212** may supply a driving signal to the first and second resistors **120**A through one end T**11** of the first resistor **120A1**. The driving signal supplied from the sensing driver **212** may be a current type or a voltage type.

According to an embodiment, when the sensing driver **212** supplies a current-type driving signal, the sensing driver **212** may include a current source IS in FIG. **8**.

According to another embodiment, when the sensing driver **212** supplies a voltage-type driving signal, the sensing driver **212** may include a supply voltage VDS and a first resistor R**1** in FIG. **8**. The first resistor (or load resistor) R**1** may be connected between the supply voltage VDS and one end T**11** of the first resistor **120A1**.

According to still another embodiment, when the sensing driver **212** selectively supplies a current-type driving signal or a voltage-type driving signal, the sensing driver **212** may include first and second switches S**1** and S**2** in addition to the current source IS, the supply voltage VDS, and the first resistor R**1**, and the camera module **1000** may further include third to sixth switches S**3** to S**6** and a resistor R**2**. Turn-on and turn-off operations of the first to sixth switches S**1** to S**6** may be controlled by the main board of the control circuit **200** shown in FIG. **1**. To this end, the control circuit **200**A may further include a separate switch controller **230**. The switch controller **230** may generate and output switch control signals for turning on or off the first to sixth switches **S1** to **S6**.

The first switch S**1** may be disposed between the constant current source IS and one end T**11** of the first resistor **120A1**, and the second switch S2 may be disposed between the resistor R1 and one end T11 of the first resistor 120A1.

The third switch S3 may be disposed between the temperature information measurer 214 and one end T11 of the first resistor 120A1, and the fourth switch S4 may be disposed between the temperature information measurer 214 and the opposite end T22 of the second resistor 120A2.

The fifth switch S5 may be disposed between the opposite end T22 of the second resistor 120A2 and the reference potential (or ground), and the sixth switch S6 may be disposed between the opposite end T22 of the second resistor 120A2 and the resistor R2. The seventh switch S7 may be disposed between the opposite end T12 of the first resistor 120A1 and one end T21 of the second resistor 120A2. The second resistor R2 may be disposed between the sixth switch S6 and the reference potential.

The temperature information measurer 214 may be connected to the resistor 120A to measure the temperature information of the resistor 120S.

When the sensing driver 212 supplies a current-type driving signal, the temperature information measurer 214 may be connected to one end T11 of the first resistor 120A1 to measure temperature information of the first and second resistors 120A1 and 120A2.

Alternatively, when the sensing driver 212 supplies a voltage-type driving signal, the temperature information measurer 214 may be connected to the opposite end T22 of the second resistor 120A2 to measure temperature information of the first and second resistors 120A1 and 120A2.

That is, the temperature information measurer 214 may measure the voltage VS1 at one end T11 of the first resistor 120A1 or the voltage VS2 at the opposite end T22 of the second resistor 120A2, and may measure temperature information of the first and second resistors 120A1 and 120A2 based on the measured voltage VS1 or VS2. To this end, the temperature information measurer 214 may include an analog/digital converter 214A. The analog/digital converter 214A may measure the voltage VS1 or VS2, may convert the measured voltage VS1 or VS2 into a digital form, and may output the result of the conversion as temperature information of the resistor 120A through the output terminal OUT.

Hereinafter, the operation of measuring temperature information of the first and second resistors 120A1 and 120A2 by the temperature sensor 210A will be described.

FIG. 9 shows an equivalent circuit of the camera module shown in FIG. 8 when a driving signal is supplied in the form of current.

First, the operation of the temperature information measurer 214 when the sensing driver 212 supplies a driving signal in the form of current will be described below with reference to FIGS. 8 and 9.

The first, third, fifth and seventh switches S1, S3, S5 and S7 are turned on, and all of the remaining switches, i.e. the second, fourth and sixth switches S2, S4 and S6 and the eighth to tenth switches S8 to S10, are turned off. Accordingly, the camera module shown in FIG. 8 may realize electric connection as shown in FIG. 9.

The eighth switch S8 may be disposed between a resistor R3 and one end T11 of the first resistor 120A1, the ninth switch S9 may be disposed between a resistor R4 and one end T21 of the second resistor 120A2, and the tenth switch S10 may be disposed between the opposite end T12 of the first resistor 120A1 and the reference potential. In addition, the resistor R3 may be disposed between a supply voltage VDH1 and the eighth switch S8, and the resistor R4 may be disposed between a supply voltage VDH2 and the ninth switch S9.

Referring to FIG. 9, the current I output from the constant current source IS flows in the direction of the arrow. In this case, the voltage VS1 sensed by the temperature information measurer 214 is expressed using Equation 1 below.

$$VS1 = I \times RT \quad \text{[Equation 1]}$$

Here, RT represents the resistance value obtained by summing the resistance value RT1 of the first resistor 120A1 and the resistance value RT2 of the second resistor 120A2.

The sensed voltage VS1 in Equation 1 is converted into a digital form by the analog/digital converter 214A, and is output as the temperature information of the first and second resistors 120A1 and 120A2 through the output terminal OUT.

The temperatures of the first and second resistors 120A1 and 120A2 may be estimated using the temperature information output through the output terminal OUT. That is, in Equation 1, since the current I is a constant fixed value supplied from the constant current source IS, RT can be determined using VS1. If the first and second resistors 120A1 and 120A2 serve as negative thermistors having resistance values RT1 and RT2 that are inversely proportional to temperature, the resistance value RT decreases as the temperature increases. On the other hand, if the first and second resistors 120A1 and 120A2 serve as positive thermistors having resistance values RT1 and RT2 that are proportional to temperature, the resistance value RT increases as the temperature increases. In this way, the digital-type voltage VS1 output from the temperature sensor 214 through the output terminal OUT may be converted into the temperature of the resistor 120A.

FIG. 10 shows an equivalent circuit of the camera module shown in FIG. 8 when a driving signal is supplied in the form of voltage.

First, the operation of the temperature information measurer 214 when the sensing driver 212 supplies a driving signal in the form of voltage will be described below with reference to FIGS. 8 and 10.

The second, fourth, sixth and seventh switches S2, S4, S6 and S7 are turned on, and the first, third and fifth switches S1, S3 and S5 and the eighth to tenth switches S8 to S10 are turned off. Accordingly, the camera module shown in FIG. 8 may realize electric connection as shown in FIG. 10.

Referring to FIG. 10, when a voltage-type driving signal is applied from the supply voltage VDS through the resistor R1, the voltage VS2 at the opposite end T22 of the second resistor 120A2 sensed by the temperature information measurer 214 is expressed using Equation 2 below.

$$VS2 = VDS \cdot \frac{R2}{RT + R2} \quad \text{[Equation 2]}$$

Here, RT represents the resistance value obtained by summing the resistance value RT1 of the first resistor 120A1 and the resistance value RT2 of the second resistor 120A2 as described above, VDS represents the supply voltage, which is a fixed value, and R2 represents the external resistor, which has a fixed resistance value. In Equation 2, the value of the first resistor R1 is a negligible value, and thus is omitted. However, if the value of the first resistor R1 is applied, Equation 2 may be expressed as Equation 3 below.

$$VS2 = VDS \cdot \frac{R2}{RT + R2 + R1} \quad \text{[Equation 3]}$$

The sensed voltage VS2 may be converted into a digital form by the analog/digital converter **214**A, and may be output as the temperature information of the resistor **120**A through the output terminal OUT.

The temperature of the resistor **120**A can be determined using the temperature information output through the output terminal OUT. That is, in Equation 2, since the supply voltage VDS and the value of the second resistor R2 are fixed values, RT can be determined using VS**2**. Alternatively, in Equation 3, since the supply voltage VDS and the values of the first and second resistors R**1** and R**2** are fixed values, RT can be determined using VS**2**. If the first and second resistors **120A1** and **120A2** serve as negative thermistors having resistance values RT**1** and RT**2** that are inversely proportional to temperature, the resistance value RT decreases as the temperature increases. On the other hand, if the first and second resistors **120A1** and **120A2** serve as positive thermistors having resistance values RT**1** and RT2 that are proportional to temperature, the resistance value RT increases as the temperature increases. In this way, the digital-type voltage VS**2** output from the temperature sensor **214** through the output terminal OUT may be converted into the temperature of the resistor **120**A.

Hereinafter, an operation of heating the liquid lens **110**A using the first and second resistors **120**A**1** and **120**A**2** by the heating controller **220**A will be described.

When the heating controller **220**A intends to heat the liquid lens **110**A using at least one of the first or second resistor **120**A**1** or **120**A**2**, the first to fourth, sixth and seventh switches S**1** to S**4**, S**6** and S**7** associated with sensing of temperature may be turned off.

In order to allow the first resistor **120**A**1** to generate heat, the first heating driver **220**A**1** may include a supply voltage VDH**1**, a resistor R**3**, and an eighth switch S**8**, and the camera module **1000** may further include a tenth switch S**10**. The resistor R3 may be disposed between the supply voltage VDH1 and the eighth switch S**8**. When the eighth switch S**8** is turned on, the resistor R3 may be connected between the supply voltage VDH**1** and one end T**11** of the first resistor **120**A**1**.

When the eighth and tenth switches S**8** and S**10** are turned on, a first heating signal is supplied from the first heating driver **220**A**1** to the first resistor **120**A**1**, whereby the first resistor **120**A**1** may generate heat.

In order to allow the second resistor **120**A**2** to generate heat, the second heating driver **220**A**2** may include a supply voltage VDH**2**, a resistor R**4**, and a ninth switch S**9**. The resistor R**4** may be disposed between the supply voltage VDH**2** and the ninth switch S**9**. When the ninth switch S**9** is turned on, the resistor R**4** may be connected between the supply voltage VDH**2** and one end T**21** of the second resistor **120**A**2**.

When the fifth and ninth switches S**5** and S**9** are turned on, a second heating signal is supplied from the second heating driver **220**A**2** to the second resistor **120**A**2**, whereby the second resistor **120**A**2** may generate heat.

In addition, in FIG. **8**, when the fifth and eighth to tenth switches S**5** and S**8** to S**10** are simultaneously turned on, the first and second resistors **120**A**1** and **120**A**2** may generate heat at the same time.

As described above, in order to allow the first and second resistors **120**A**1** and **120**A**2** to selectively perform the operation of sensing the temperature of the liquid lens **110**A and the operation of heating the liquid lens **110**A, the switch controller **230** may generate and output switch control signals for turning on or off the first to tenth switches S**1** to S**10**.

In FIG. **8**, it is possible to sense the temperature of the liquid lens **110**A using the first to eighth switches S**1** to S**7** and to heat the liquid lens **110**A using the fifth and eighth to tenth switches S**5** and S**8** to S**10**.

The switch controller **230** may turn on/off the switches S**1** to S**10** for respective operations as shown in Table 1 below.

TABLE 1

Classification	OP1	OP2	OP3	OP4	OP5
S1	1	0	0	0	0
S2	0	1	0	0	0
S3	1	0	0	0	0
S4	0	1	0	0	0
S5	1	0	0	1	1
S6	0	1	0	0	0
S7	1	1	0	0	0
S8	0	0	1	0	1
S9	0	0	0	1	1
S10	0	0	1	0	1

In Table 1, OP**1** represents the switching operation of sensing the temperature of the liquid lens **110**A when a current-type driving signal is applied thereto, OP2 represents the switching operation of sensing the temperature of the liquid lens **110**A when a voltage-type driving signal is applied thereto, OP**3** represents the switching operation of controlling only the first resistor **120A1** to generate heat, OP**4** represents the switching operation of controlling only the second resistor **120**A**2** to generate heat, and OP**5** represents the switching operation of controlling the first and second resistors **120A1** and **120**A**2** to simultaneously generate heat. In Table 1, represents that a corresponding switch is in a turned-off state, and "1" represents that a corresponding switch is in a turned-on state.

Meanwhile, an embodiment in which the resistor **120**B shown in FIG. **6** is used to sense the temperature of the liquid lens **110**A or to heat the liquid lens **110**A will be described below with reference to FIG. **11**.

FIG. **11** is a diagram for explaining the operation of another embodiment of the camera module **1000** shown in FIG. **1**.

Unlike the illustration of FIG. **8**, the camera module **1000** shown in FIG. **11** includes only one resistor **120**B. Except for this, the camera module **1000** shown in FIG. **11** is the same as the camera module **1000** shown in FIG. **8**. Thus, only parts different from those of FIG. **8** will be described with reference to FIG. **11**, and a description of the same parts is omitted. That is, the temperature sensor **210**A and the heating driver **220**A**1** shown in FIG. **11** respectively correspond to the temperature sensor **210**A and the first heating driver **220**A**1** shown in FIG. **8**.

Referring to FIG. **11**, the first switch S**1** may be disposed between the constant current source IS and one end T**31** of the resistor **120**B, and the second switch S**2** may be disposed between the resistor R1 and one end T**31** of the resistor **120**B.

The third switch S3 may be disposed between the temperature information measurer **214** and one end T**31** of the resistor **120**B, and the fourth switch S**4** may be disposed between the temperature information measurer **214** and the opposite end T**32** of the resistor **120**B.

The fifth switch S**5** may be disposed between the opposite end T**32** of the resistor **120**B and the reference potential (or ground), and the sixth switch S**6** may be disposed between the opposite end T**32** of the resistor **120**B and the resistor R**2**. The resistor R2 may be disposed between the sixth switch S**6** and the reference potential.

The eighth switch S8 may be disposed between the resistor R3 and one end T31 of the resistor 120B.

The electrical connection relationships in the case in which the resistor 120B is used in order to sense the temperature of the liquid lens 110A will be described below.

The temperature sensor 210A may be connected to one end T31 of the resistor 120B. To this end, one end T31 of the resistor 120B may be electrically connected to the temperature sensor 210A disposed on the main board (e.g. 480 shown in FIG. 13) via the first connection substrate 132. Alternatively, as will be described later, the temperature sensor 210A may also be connected to the opposite end T32 as well as one end T31 of the resistor 120B. To this end, one end T31 and the opposite end T32 of the resistor 120B may be electrically connected to the temperature sensor 210A disposed on the main board via the first connection substrate 132.

When the fifth switch S5 is turned on, the opposite end T32 of the resistor 120B may be connected to the reference potential (or ground), and when the sixth switch S6 is turned on, the opposite end T32 of the resistor 120B may be connected to the resistor R2. In this case, the opposite end T32 of the resistor 120B may be connected to the reference potential or the resistor R2 via the first connection substrate 132 and the main board.

The electrical connection relationships in the case in which the resistor 120B is used in order to heat the liquid lens 110A will be described below.

In order to control the generation of heat by the resistor 120, the heating controller 220 shown in FIG. 1 serves to supply a heating signal to one end of the resistor 120. In the embodiment, when the resistor 120 shown in FIG. 1 includes the resistor 120B, as shown in FIGS. 6 and 11, the heating controller 220A may include only one first heating driver 220A1.

The first heating driver 220A1 may supply a first heating signal to one end T31 of the resistor 120B. To this end, when the eighth switch S8 is turned on, the first heating driver 220A1 may be connected to one end T31 of the resistor 120B, and when the fifth switch S5 is turned on, the opposite end T32 of the resistor 120B may be connected to the reference potential. For example, one end T31 of the resistor 120B may be connected to the first heating driver 220A1 of the main board via the first connection substrate 132, and the opposite end T32 thereof may be connected to the reference potential via the first connection substrate 132 and the main board.

According to the embodiment, the temperature sensor 210A may include a sensing driver 212 and a temperature information measurer 214, like the illustration of FIG. 8.

The sensing driver 212 serves to supply a driving signal (or a sensing signal) to the resistor 120B. For example, the sensing driver 212 may supply a driving signal to the resistor 120B through one end T31 of the resistor 120B.

When the sensing driver 212 supplies a current-type driving signal, the temperature information measurer 214 may be connected to one end T31 of the resistor 120B, and may measure temperature information of the resistor 120B.

Alternatively, when the sensing driver 212 supplies a voltage-type driving signal, the temperature information measurer 214 may be connected to the opposite end T32 of the resistor 120B, and may measure temperature information of the resistor 120B.

That is, the temperature information measurer 214 may measure the voltage VS1 at one end T31 of the resistor 120B or the voltage VS2 at the opposite end T32 of the resistor 120B, and may measure temperature information of the resistor 120B based on the measured voltage VS1 or VS2.

Since the switching operations of the first to sixth switches for measurement of temperature information of the resistor 120B by the temperature sensor 210A shown in FIG. 11 are the same as described with reference to FIG. 8, a duplicate description thereof is omitted.

In addition, when the first heating driver 220A1 shown in FIG. 11 intends to allow the resistor 120B to generate heat, the fifth and eighth switches S5 and S8 may be turned on, and the first to fourth and sixth switches S1 to S4 and S6 may be turned off. Accordingly, a first heating signal may be supplied from the first heating driver 220A1 to the resistor 120B, whereby the resistor 120B may generate heat.

Similar to the illustration of FIG. 8, in the camera module shown in FIG. 11, in order to allow the resistor 120B to selectively perform the operation of sensing the temperature of the liquid lens 110A and the operation of heating the liquid lens 110A, the switch controller 230 may generate and output switch control signals for turning on or off the first to sixth and eighth switches S1 to S6 and S8.

In FIG. 11, it is possible to sense the temperature of the liquid lens 110A using the first to sixth switches S1 to S6 and to heat the liquid lens 110A using the fifth and eighth switches S5 and S8.

The switch controller 230 shown in FIG. 11 may turn on/off the switches S1 to S6 and S8 for respective operations as shown in Table 2 below.

TABLE 2

Classification	OP1	OP2	OP3
S1	1	0	0
S2	0	1	0
S3	1	0	0
S4	0	1	0
S5	1	0	1
S6	0	1	0
S8	0	0	1

In Table 2, OP1 represents the switching operation of sensing the temperature of the liquid lens 110A when a current-type driving signal is applied thereto, OP2 represents the switching operation of sensing the temperature of the liquid lens 110A when a voltage-type driving signal is applied thereto, and OP3 represents the switching operation of controlling the resistor 120B to generate heat. In Table 2, "0" represents that a corresponding switch is in a turned-off state, and "1" represents that a corresponding switch is in a turned-on state.

Hereinafter, a control method of the above-described camera module 1000 will be described with reference to FIGS. 1, 8, 11 and 12.

FIG. 12 is a flowchart for explaining a control method 500 of the camera module 1000 according to an embodiment.

Referring to FIG. 12, the temperature of the liquid lens 110A is sensed first (step 510). Step 510 may be performed by the temperature sensor 210 or 210A.

Referring to FIG. 8, in order to sense the temperature of the liquid lens 110A, the switching controller 230 turns on the seventh switch S7, turns off the eighth to tenth switches S8 to S10, and controls the switching operations of the first to sixth switches S1 to S6 such that the temperature sensor 210A measures temperature information of the resistor 120A (refer to OP1 and OP2 described in Table 1 above).

Alternatively, referring to FIG. 11, in order to sense the temperature of the liquid lens 110A, the switching controller

230 turns off the eighth switch S8, and controls the switching operations of the first to sixth switches S1 to S6 such that the temperature sensor 210A measures temperature information of the resistor 120B (refer to OP1 and OP2 described in Table 2 above).

After step 510, a difference between the sensed temperature and the set target temperature of the liquid lens 110A is detected (step 520). Step 520 may be performed by the control circuit 200. For example, step 520 may be performed by the switch controller 230.

When there is a difference between the sensed temperature and the set target temperature of the liquid lens 110A, power is applied to the resistor 120A or 120B (step 530).

Referring to FIG. 8, when the temperature difference is large, the switching controller 230 may generate switch control signals such that the fifth, eighth, ninth and tenth switches S5, S8, S9 and S10 in FIG. 8 are simultaneously turned on (refer to OP5 described in Table 1 above). Accordingly, the heating controller 220A may control the first and second resistors 120A1 and 120A2 to simultaneously generate heat, thereby heating the liquid lens 110A within a short time.

However, when the temperature difference is not large, the switching controller 230 may turn on the eighth and tenth switches S8 and S10, or may turn on the fifth and ninth switches S5 and S9 (refer to OP3 or OP4 described in Table 1 above). Accordingly, the heating controller 220A may perform control such that any one of the first and second resistors 120A1 and 120A2 generates heat to heat the liquid lens 110A.

Also, when there is no difference between the sensed temperature and the set target temperature of the liquid lens 110A, the current state is maintained (step 540). To this end, the switching controller 230 may generate switch control signals such that the fifth and eighth to tenth switches S5 and S8 to S10 shown in FIG. 8 are turned off. Accordingly, neither of the first and second resistors 120A1 and 120A2 generates heat.

Hereinafter, an embodiment of the camera module 1000 according to the above-described embodiment will be described with reference to FIGS. 13 and 14.

FIG. 13 is an exploded perspective view of an embodiment 1000A of the camera module 1000 shown in FIG. 1.

Referring to FIG. 13, the camera module 1000A may include a lens assembly, an image sensor 300, and a main board 480. Here, the lens assembly, the image sensor 300, and the main board 480 respectively correspond to embodiments of the lens assembly, the image sensor 300, and the control circuit 200 shown in FIG. 1.

In addition, the camera module 1000A may further include a first cover 410 and a middle base 450. In addition, the camera module 1000A may further include a sensor base 460 and a filter 470. In addition, the camera module 1000A may further include a circuit cover 472. The circuit cover 472 may have an electromagnetic shielding function.

According to the embodiment, at least one of the components 420 to 470 of the camera module 1000A shown in FIG. 13 may be omitted. Alternatively, at least one component different from the components 420 to 470 shown in FIG. 13 may be further included in the camera module 1000A.

Referring to FIG. 13, the lens assembly may include at least one of a liquid lens module 130, a first lens unit 420, a holder 430, or a second lens unit 440, and may be disposed on a main board 480. One of the first lens unit 420 and the second lens unit 440 of the lens assembly may be omitted.

In the lens assembly, the first lens unit 420 and the second lens unit 440 may be respectively referred to as a "first solid lens unit" and a "second solid lens unit" in order to be distinguished from the liquid lens 110A.

The first lens unit 420 may be disposed at the upper side of the lens assembly, and may be a region on which light is incident from outside the lens assembly. That is, the first lens unit 420 may be disposed above the liquid lens module 130 within the holder 430. The first lens unit 420 may be implemented using a single lens, or may be implemented using two or more lenses that are aligned along a center axis to form an optical system. Here, the center axis may be the optical axis LX of the optical system, which is formed by the first lens unit 420, the liquid lens module 130, and the second lens unit 440 included in the camera module 1000A, or may be an axis parallel to the optical axis LX. The optical axis LX may correspond to the optical axis of the image sensor 300. That is, the first lens unit 420, the liquid lens module 130, the second lens unit 440, and the image sensor 300 may be aligned along the optical axis LX through active alignment (AA). Here, "active alignment" may mean an operation of aligning the optical axes of the first lens unit 420, the second lens unit 440, and the liquid lens module 130 with each other and adjusting the axial or distance relationships between the image sensor 300, the lens units 420 and 440, and the liquid lens module 130 in order to acquire an improved image.

FIG. 14 is a view for explaining the holder 430 and the liquid lens module 130 shown in FIG. 13. That is, FIG. 14 is an exploded perspective view of the holder 430 and the liquid lens unit 130. The holder 430 shown in FIG. 14 may include first and second holes HO1 and HO2 and first to fourth sidewalls.

The first and second holes HO1 and HO2 may be respectively formed in the upper portion and the lower portion of the holder 430 to open the upper portion and the lower portion of the holder 430, respectively. Here, the first hole HO1 and the second hole HO2 may be through-holes. The first lens unit 420 may be accommodated in, mounted in, seated in, in contact with, fixed to, provisionally fixed to, supported by, coupled to, or disposed in the first hole HO1, which is formed in the holder 430, and the second lens unit 440 may be accommodated in, mounted in, seated in, in contact with, fixed to, provisionally fixed to, supported by, coupled to, or disposed in the second hole HO2, which is formed in the holder 430.

In addition, the first and second sidewalls of the holder 430 may be disposed so as to face each other in a direction perpendicular to the direction of the optical axis LX (e.g. in the x-axis direction), and the third and fourth sidewalls may be disposed so as to face each other in a direction perpendicular to the x-axis direction and to the direction of the optical axis LX (e.g. in the y-axis direction). In addition, as illustrated in FIG. 14, the first sidewall of the holder 430 may include a third opening OP3, and the second sidewall thereof may include a fourth opening OP4, having a shape that is the same as or similar to that of the third opening OP3. Thus, the third opening OP3 formed in the first sidewall and the fourth opening OP4 formed in the second sidewall may be disposed so as to face each other in a direction perpendicular to the direction of the optical axis LX (e.g. in the x-axis direction).

The inner space in the holder 430, in which the liquid lens module 130 is disposed, may be open due to the third and fourth openings OP3 and OP4. In this case, the liquid lens module 130 may be inserted through the third or fourth opening OP3 or OP4 so as to be mounted in, seated in, in contact with, fixed to, provisionally fixed to, supported by, coupled to, or disposed in the inner space in the holder **430**. For example, the liquid lens module **130** may be inserted into the inner space in the holder **430** through the third opening OP**3**.

As such, in order to allow the liquid lens module **130** to be inserted into the inner space in the holder **430** through the third or fourth opening OP**3** or OP**4**, the size of the third or fourth opening OP**3** or OP**4** in the holder **430** in the direction of the optical axis LX may be greater than the cross-sectional area of the liquid lens module **130** in the y-axis direction and the z-axis direction. For example, the height H corresponding to the size of each of the third and fourth openings OP**3** and OP**4** in the direction of the optical axis LX may be greater than the thickness TO of the liquid lens module **130**.

The second lens unit **440** may be disposed below the liquid lens module **130** within the holder **430**. The second lens unit **440** may be disposed so as to be spaced apart from the first lens unit **420** in the optical-axis direction (e.g. in the z-axis direction).

The light introduced into the first lens unit **420** from outside the camera module **1000**A may pass through the liquid lens module **130** and may be introduced into the second lens unit **440**. The second lens unit **440** may be implemented using a single lens, or may be implemented using two or more lenses, which are aligned along the center axis to form an optical system.

Unlike the liquid lens module **130**, each of the first lens unit **420** and the second lens unit **440** may be a solid lens formed of glass or plastic, but the embodiments are not limited to any specific material of each of the first lens unit **420** and the second lens unit **440**.

Referring again to FIG. 13, the first cover **410** may be disposed so as to surround the holder **430**, the liquid lens module **130**, and the middle base **450**, and may protect these components **430**, **130** and **450** from external impacts. In particular, since the first cover **410** is disposed, a plurality of lenses, which form the optical system, may be protected from external impacts.

In addition, in order to allow the first lens unit **420** disposed in the holder **430** to be exposed to external light, the first cover **410** may include an upper opening **410**H formed in the upper surface of the first cover **410**.

In addition, the first cover **410** may be disposed so as to cover the upper surface and the first to fourth sidewalls of the holder **430**.

In addition, the middle base **450** may be disposed so as to surround the second hole HO**2** in the holder **430**. To this end, the middle base **450** may include an accommodating hole **450**H for accommodating the second hole HO**2** therein.

In the same manner as the upper opening **410**H in the first cover **410**, the accommodating hole **450**H may be formed near the center of the middle base **450** at a position corresponding to the position of the image sensor **300**, which is disposed in the camera module **1000**A.

The middle base **450** may be mounted on the main board **480** so as to be spaced apart from a circuit element **481** on the main board **480**. That is, the holder **430** may be disposed on the main board **480** so as to be spaced apart from the circuit element **481**.

The main board **480** may be disposed below the middle base **450**, and may include a recess in which the image sensor **300** may be mounted, seated, tightly disposed, fixed, provisionally fixed, supported, coupled, or accommodated, the circuit element **481**, a connection part (or an FPCB) **482**, and a connector **483**.

The circuit element **481** of the main board **480** may constitute a control module, which controls the liquid lens module **130** and the image sensor **300**. The circuit element **481** may include at least one of a passive element and an active element, and may have any of various areas and heights. The circuit element **481** may be provided in a plural number, and may have a height greater than the height of the main board **480** so as to protrude outwards. The plurality of circuit elements **481** may be disposed so as not to overlap the holder **430** in the direction parallel to the optical axis LX. For example, the plurality of circuit elements **481** may include a power inductor, a gyro sensor, and the like, but the embodiments are not limited to any specific type of the circuit elements **481**.

In addition, the circuit elements **481** may calculate the temperature of the resistor **120**A or **120**B using the voltage values VS**1** and VS**2** output through the output terminal OUT shown in FIG. **1**, and may transmit the calculated temperature to the outside through the connector **483**. In addition, the circuit elements **481** may include the first to tenth switches S**1** to S**10** shown in FIG. **8** or the first to sixth and eighth switches S**1** to S**6** and S**8** shown in FIG. **11**, and may serve as the switch controller **230** controlling the on/off operation of the switches S**1** to S**10** or the switches S**1** to S**6** and S**8**.

The main board **480** may include a holder area in which the holder **430** is disposed and an element area in which the plurality of circuit elements **481** is disposed.

The main board **480** may be implemented as a rigid flexible printed circuit board (RFPCB) including the FPCB **482**. The FPCB **482** may be bent depending on the requirement of the space in which the camera module **1000**A is mounted.

Meanwhile, the connector **483** may electrically connect the main board **480** to a power supply or other devices (e.g. an application processor) outside the camera module **1000**A.

Meanwhile, some of the plurality of circuit elements **481** shown in FIG. **13** may cause electromagnetic interference (EMI) or noise. In particular, among the plurality of circuit elements **481**, a power inductor **481-1** may cause greater EMI than other elements. In order to block EMI or noise, the circuit cover **472** may be disposed so as to cover the circuit elements **481** disposed in the element area of the main board **480**.

In addition, when the circuit cover **472** is disposed so as to cover the circuit elements **481**, the circuit elements **481** disposed on the main board **480** may be protected from external impacts. To this end, the circuit cover **472** may include an accommodating space for accommodating therein and covering the circuit elements **481**, in consideration of the shape and position of the circuit elements **481** disposed on the main board **480**.

Meanwhile, the filter **470** may filter light within a specific wavelength range, among the light that has passed through the first lens unit **420**, the liquid lens module **130**, and the second lens unit **440**. The filter **470** may be an infrared (IR) light blocking filter or an ultraviolet (UV) light blocking filter, but the embodiments are not limited thereto. The filter **470** may be disposed above the image sensor **300**. The filter **470** may be disposed inside the sensor base **460**.

The sensor base **460** may be disposed below the middle base **450**, and may be attached to the main board **480**. The sensor base **460** may surround the image sensor **300**, and may protect the image sensor **300** from foreign substances or external impacts.

The main board **480** may be disposed below the sensor base **460**, the sensor base **460** may be mounted on the main board **480** so as to be spaced apart from the circuit elements **481**, and the holder **430** in which the middle base **450**, the second lens unit **440**, the liquid lens module **130**, and the first lens unit **420** are disposed may be disposed above the sensor base **460**.

Hereinafter, a comparison between a comparative example and the camera module according to the embodiment will be made. The comparative example set forth herein is merely illustrative in order to help understand the effects of the camera module according to the embodiment, and is not a related or conventional art.

FIGS. **15**(*a*) and (*b*) are partial plan views of a camera module according to the comparative example.

The camera module according to the comparative example shown in FIGS. **15**(*a*) and (*b*) includes a liquid lens **10**, a thermistor **20**, and a heater **30**.

The liquid lens **10** may include first electrodes E**1**, which are individual electrodes, and a second electrode E**2**, which is a common electrode. Here, the first electrodes E**1** and the second electrode E**2** respectively correspond to the first electrodes E**1** and the second electrode E**2** according to the above-described embodiment. The thermistor **20** is used to sense the temperature of the liquid lens **10**. In addition, the heater **30** serves to heat the liquid lens **10**.

As shown in FIG. **15**(*a*), in the liquid lens **10** according to the comparative example, the thermistor **20** is disposed on the surface on which the second electrode E**2** is disposed (e.g. corresponding to the second surface SF**2** shown in FIG. **3**) so as to be spaced apart from the second electrode E**2**. However, when the thermistor **20** is disposed on the second surface SF**2**, on which the common electrode E**2** is disposed, the thermistor **20** may affect the common electrode E**2**, leading to an operational problem. In contrast, in the case of the camera module according to the embodiment, the resistor **120**A or **120**B, which serves as the thermistor **20** or the heater **30**, is disposed on the first surface SF**1**, on which the individual electrodes E**1** are disposed, rather than being disposed on the second surface SF**2**, on which the common electrode E**2** is disposed, whereby influence on the common electrode E**2**, which is a reference electrode, may be prevented, and thus operational stability may be secured.

In addition, in the case of the comparative example, the thermistor **20** is disposed on the surface on which the second electrode E**2** shown in FIG. **15**(*a*) is disposed (i.e. corresponding to SF**2** of the embodiment), rather than being disposed on the first surface (i.e. corresponding to SF**1** of the embodiment), on which the first electrodes E**1** are disposed. However, when the thermistor **20** is disposed on the second surface SF**2**, which is has a smaller area than the first surface SF**1**, the area in which to dispose the thermistor **20** is small. In order to increase this area, it is required to increase the overall size of the liquid lens **10**. If the size of the liquid lens **10** is increased, the size of the lens assembly accommodating the liquid lens **10** may be increased, which may result in an increase in the overall size of the camera module. Accordingly, it is difficult to apply the comparative example to a camera module having a reduced bezel or no bezel. In contrast, in the case of the camera module **1000** or **1000**A according to the embodiment, the resistor **120**A or **120**B, which performs the same function as the thermistor **20** of the comparative example, is disposed on the first surface SF**1**, which is wider than the second surface SF**2** of the first plate P**1** in the liquid lens **110**A. Thus, the resistor **120**A or **120**B, which serves as the thermistor **20**, can be disposed in a larger area on the first surface SF**1** compared to the comparative example, obviating the need to increase the overall size of the liquid lens **110** or **110**A. Accordingly, in the camera module according to the embodiment, it is possible to easily reduce the size of a bezel or eliminate a bezel. In particular, considering that the temperature of the liquid lens **110** is more accurately sensed when the size of the thermistor **20** is larger, it is apparent that the embodiment is capable of more accurately sensing the temperature of the liquid lens **110** than the comparative example because the resistor **120** (**120**A and **120***b*) of the embodiment, which serves as the thermistor **20**, can be formed over a larger area than the thermistor **20** of the comparative example.

In addition, in the case of the camera module according to the comparative the heater **30** is disposed on a surface on which the first electrodes E**1** are disposed, as shown in FIG. **15**(*b*), and the thermistor **20** is disposed on a surface on which the second electrode E**2** is disposed, as shown in FIG. **15**(*a*). In contrast, in the case of the camera module according to the embodiment, since the resistor **120**A or **120**B, which is capable of serving both as the thermistor **20** and as the heater **30** of the comparative example, is disposed on the first surface SF**1** of the first plate P**1**, utilization of space is improved.

Although only a limited number of embodiments have been described above, various other embodiments are possible. The technical contents of the above-described embodiments may be combined into various forms as long as they are not incompatible with one another, and thus may be implemented in new embodiments.

An optical device may be implemented using a camera module **1000** or **1000**A including the liquid lens according to the embodiments described above. Here, the optical device may include a device that may process or analyze optical signals. Examples of the optical device may include camera/video devices, telescopic devices, microscopic devices, an interferometer, a photometer, a polarimeter, a spectrometer, a reflectometer, an auto-collimator, and a lens-meter, and the embodiments may be applied to optical devices that may include a lens assembly.

In addition, the optical device may be implemented in a portable device such as, for example, a smartphone, a laptop computer, and a tablet computer. Such an optical device may include the camera module **1000** or **1000**A, a display unit (not shown) configured to output an image, a battery (not shown) configured to supply power to the camera module **1000** or **1000**A, and a body housing in which the camera module **1000** or **1000**A, the display unit, and the battery are mounted. The optical device may further include a communication module, which may communicate with other devices, and a memory, which may store data. The communication module and the memory may also be mounted in the body housing.

It will be apparent to those skilled in the art that various changes in form and details may be made without departing from the spirit and essential characteristics of the disclosure set forth herein. Accordingly, the above detailed description is not intended to be construed to limit the disclosure in all aspects and to be considered by way of example. The scope of the disclosure should be determined by reasonable interpretation of the appended claims and all equivalent modifications made without departing from the disclosure should be included in the following claims.

MODE FOR INVENTION

Various embodiments have been described in the best mode for carrying out the disclosure.

INDUSTRIAL APPLICABILITY

A camera module including a liquid lens and a control method thereof according to embodiments may be used in camera/video devices, telescopic devices, microscopic devices, an interferometer, a photometer, a polarimeter, a spectrometer, a reflectometer, an auto-collimator, a lens-meter, a smartphone, a laptop computer, a tablet computer, etc.

The invention claimed is:

1. A camera module, comprising:
- a liquid lens comprising a first plate, a common electrode, and an individual electrode disposed on a first surface of the first plate;
- a resistor disposed on the first surface of the first plate so as to be spaced apart from the individual electrode;
- a temperature sensor connected to the resistor and configured to supply a sensing signal to the resistor;
- a heating controller connected to the resistor and configured to supply a heating signal to the resistor;
- a first switch connecting the resistor and the temperature sensor;
- a second switch connecting the resistor and the heating controller; and
- a switch controller configured to control the first switch and the second switch,
- wherein the resistor is configured to sense a temperature of the liquid lens when the first switch is turned on by the switch controller and heat the liquid lens when the second switch is turned on by the switch controller,
- wherein the first plate comprises a second surface formed opposite the first surface and which has an area that is smaller than an area of the first surface, and
- wherein the common electrode is a reference electrode disposed on the second surface.

2. The camera module according to claim **1**, wherein the temperature sensor comprises a sensing driver configured to supply the sensing signal to one end of the resistor, and
- wherein the heating controller comprises a heating driver configured to supply the heating signal to the one end of the resistor.

3. The camera module according to claim **2**, wherein the first switch is disposed between the resistor and the sensing driver, and
- wherein the second switch is disposed between the resistor and the heating driver.

4. The camera module according to claim **2**, wherein the resistor comprises an opposite end connected to a reference potential.

5. The camera module according to claim **3**, further comprising:
- a connection substrate connected to the individual electrode and the resistor,
- wherein the resistor comprises first and second resistors, the first and second resistors being disposed so as to face each other, with a center of the liquid lens interposed therebetween.

6. The camera module according to claim **5**, wherein the temperature sensor is connected to one end of the second resistor via one end of the first resistor and an opposite end of the first resistor.

7. The camera module according to claim **6**, wherein the heating controller is connected to the one end of the first resistor and the one end of the second resistor.

8. The camera module according to claim **7**, wherein the opposite end of the first resistor is connected to a reference potential, and
- wherein the camera module further comprises:
  - a third switch disposed between the opposite end of the first resistor and the reference potential; and
  - a fourth switch disposed between the opposite end of the first resistor and the one end of the second resistor.

9. The camera module according to claim **5**, wherein one end and an opposite end of the first resistor are disposed in a first edge area of the liquid lens, and
- wherein one end and an opposite end of the second resistor are disposed in a second edge area of the liquid lens, the second edge area being an area that is opposite the first edge area.

10. The camera module according to claim **9**, wherein the liquid lens comprises a second plate disposed on the first surface of the first plate.

11. The camera module according to claim **10**, wherein the first and second resistors are disposed between the first surface of the first plate and the second plate.

12. The camera module according to claim **10**, wherein the second plate comprises a plurality of recesses exposing the one end and the opposite end of each of the first and second resistors, and
- wherein the connection substrate comprises a plurality of protruding portions protruding toward the liquid lens to be connected to each end of the first and second resistors exposed at the plurality of recesses.

13. The camera module according to claim **12**, wherein the plurality of protruding portions protrudes from inner edge surfaces between inner corners of the connection substrate.

14. The camera module according to claim **5**, wherein the first resistor and the second resistor face each other in a first direction,
- wherein the first resistor and the second resistor have planar shapes on a plane parallel to the first and a second direction, which are symmetric to each other,
- wherein the first direction is perpendicular to the second direction, and
- wherein the second direction is perpendicular to the first direction and a third direction of an optical axis direction.

15. The camera module according to claim **1**, wherein the liquid lens comprises a first liquid and a second liquid accommodated in a cavity of the first plate,
- wherein the first plate includes a first opening and a second opening, the first and second openings defining the cavity,
- wherein the first opening has a smaller area than the second opening, and
- wherein the first opening is formed in the first surface and the second opening is formed in the second surface.

16. A camera module, comprising:
- a liquid lens, the liquid lens comprising:
  - a first plate comprising a first surface and a second surface formed opposite the first surface and which has an area that is smaller than an area of the first surface;
  - a first electrode disposed on the first surface of the first plate; and
  - a second electrode that is a reference electrode disposed on the second surface;
- a resistor disposed on the first surface and spaced apart from the first electrode;
- a temperature sensor connected to the resistor and configured to supply a sensing signal to the resistor;
- a heating controller connected to the resistor and configured to supply a heating signal to the resistor;
- a first switch connecting the resistor and the temperature sensor;

a second switch connecting the resistor and the heating controller; and

a switch controller configured to control the first switch and the second switch,

wherein the resistor is configured to sense the temperature of the liquid lens when the first switch is turned on by the switch controller and heat the liquid lens when the second switch is turned on by the switch controller.

17. The camera module according to claim **16**, wherein the first electrode includes a plurality of individual electrodes, and

wherein the second electrode includes a common electrode.

18. A method for controlling the camera module of claim **1**, the method comprising:

sensing the temperature of the liquid lens;

detecting a difference between the sensed temperature and a set target temperature of the liquid lens; and

applying power to the resistor when there is the difference between the sensed temperature and the set target temperature of the liquid lens.

19. The method of claim **18**, comprising:

maintaining a current state when there is no difference between the sensed temperature and the set target temperature of the liquid lens.

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