US Patent & Trademark Office
Patent Public Search | Text View

United States Patent Application Publication	20250258573
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	Kano; Hidekazu et al.

SENSOR MODULE, TOUCH PANEL, AND ELECTRONIC DEVICE

Abstract

A sensor module including: a piezoelectric sensor having a piezoelectric film, one or more first electrodes, and one or more second electrodes; and a touch sensor having a plurality of transmission electrodes and a plurality of reception electrodes, wherein the elastic member, the piezoelectric sensor, and the touch sensor are arranged in this order in a negative direction of a Z axis, the plurality of transmission electrodes include a plurality of first non-overlapping portions that do not overlap the plurality of reception electrodes in a Z axis direction, the plurality of reception electrodes include a plurality of second non-overlapping portions that do not overlap the plurality of transmission electrodes in the Z axis direction, and the plurality of first non-overlapping portions or the plurality of second non-overlapping portions do not overlap the one or more first electrodes and the one or more second electrodes in the Z axis direction.

Inventors: **Kano; Hidekazu (Nagaokakyo-shi, JP), Tachibana; Yuuki (Nagaokakyo-shi, JP)**

Applicant: **Murata Manufacturing Co., Ltd.** (Nagaokakyo-shi, JP)

Family ID: **1000008574321**

Appl. No.: **19/194150**

Filed: **April 30, 2025**

Foreign Application Priority Data

JP	2022-181684	Nov. 14, 2022

Related U.S. Application Data

parent WO continuation PCT/JP2023/039277 20231031 PENDING child US 19194150

Publication Classification

Int. Cl.: **G06F3/044** (20060101); **G06F3/041** (20060101)

U.S. Cl.:

CPC **G06F3/0446** (20190501); **G06F3/0416** (20130101); G06F2203/04105 (20130101)

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] The present application is a continuation of International application No. PCT/JP2023/039277, filed Oct. 31, 2023, which claims priority to Japanese Patent Application No. 2022-181684, filed Nov. 14, 2022, the entire contents of each of which are incorporated herein by reference.

TECHNICAL FIELD
[0002] The present disclosure relates to a sensor module including a sensor that detects deformation of a member.
BACKGROUND ART
[0003] Patent Document 1 describes a touch sensor including a housing, a plate, a press detecting sensor, and a position detecting sensor. The position detecting sensor, the press detecting sensor, and the plate are arranged in this order in a positive direction of a Z axis. Outer peripheral ends of the plate, the press detecting sensor, and the position detecting sensor are fixed to the housing. The position detecting sensor detects a position touched by a user on the plate.
[0004] The press detecting sensor detects a force applied to the plate by the user. The press detecting sensor includes a piezoelectric film, a first piezoelectric detection electrode, and a second piezoelectric detection electrode. The piezoelectric film is located between the first piezoelectric detection electrode and the second piezoelectric detection electrode. Each of the first piezoelectric detection electrode and the second piezoelectric detection electrode has an annular shape as viewed in a thickness direction of the touch sensor. Each of the first piezoelectric detection electrode and the second piezoelectric detection electrode is provided at an outer peripheral edge portion of the plate. [0005] Patent Document 1: Japanese Patent Application Laid-Open No. 2016-184425
SUMMARY OF THE DISCLOSURE
[0006] In a field of the touch sensor described in Patent Document 1, it is desired that a sensor which detects deformation of a member easily detects the deformation of the member.
[0007] An object of the present disclosure is to provide a sensor module in which a sensor which detects deformation of a member easily detects the deformation of the member.
[0008] A sensor module according to an embodiment of the present disclosure includes: an elastic member; a piezoelectric sensor which includes a piezoelectric film, one or more first electrodes, and one or more second electrodes; and a touch sensor which includes a plurality of transmission electrodes and a plurality of reception electrodes, the elastic member, the piezoelectric sensor, and the touch sensor are arranged in this order in a negative direction of a Z axis, each of the one or more first electrodes are on a positive side of the Z axis with respect to the piezoelectric film, each of the one or more second electrodes are on a negative side of the Z axis with respect to the piezoelectric film, the piezoelectric sensor is constructed to output a first signal when the elastic member is deformed, each of the plurality of transmission electrodes are on the negative side of the Z axis with respect to the plurality of reception electrodes, the touch sensor is constructed to output a second signal on the basis of a capacitance value when a capacitance is generated between the plurality of transmission electrodes and the plurality of reception electrodes, the plurality of transmission electrodes include a plurality of first non-overlapping portions that do not overlap the plurality of reception electrodes as viewed in a Z axis direction, the plurality of reception electrodes

include a plurality of second non-overlapping portions that do not overlap the plurality of transmission electrodes as viewed in the Z axis direction, and the plurality of first non-overlapping portions or the plurality of second non-overlapping portions do not overlap the one or more first electrodes and the one or more second electrodes as viewed in the Z axis direction.
[0009] According to the sensor module according to the embodiment of the present disclosure, the sensor which detects deformation of a member easily detects the deformation of the member.

Description

BRIEF EXPLANATION OF THE DRAWINGS
[0010] FIG. **1** is an exploded perspective view of a sensor module **1**.
[0011] FIG. **2** is a perspective view of the sensor module **1** as viewed in a positive direction of a Y axis.
[0012] FIG. **3** is a view of a piezoelectric sensor **11** as viewed in a negative direction of a Z axis.
[0013] FIG. **4** is a view of a piezoelectric film **110** as viewed in the negative direction of the Z axis.
[0014] FIG. **5** is a view of a touch sensor **12** as viewed in the negative direction of the Z axis.
[0015] FIG. **6** is a view of a plurality of reception electrodes **121**, a plurality of transmission electrodes **122**, and a piezoelectric sensor **11** as viewed in the negative direction of the Z axis.
[0016] FIG. **7** is a view illustrating a case where a user **200** touches an elastic member **10**.
[0017] FIG. **8** is a view illustrating a sensor module **1***a* according to a first modification.
[0018] FIG. **9** is a view illustrating a case where the user **200** touches the elastic member **10** included in the sensor module **1***a*.
[0019] FIG. **10** is a view illustrating a sensor module **1***b* according to a second modification.
[0020] FIG. **11** is a view illustrating a sensor module **1***c* according to a third modification.
[0021] FIG. **12** is a view illustrating a piezoelectric sensor **11***d* according to a first modification of a piezoelectric sensor **11***c*.
[0022] FIG. **13** is a view illustrating a piezoelectric sensor **11***e* according to a second modification of the piezoelectric sensor **11***c*.
[0023] FIG. **14** is a view illustrating a touch panel TP including the sensor module **1**.
[0024] FIG. **15** is a view illustrating a smartphone SP including the touch panel TP.
DETAILED DESCRIPTION
First Embodiment
[0025] Hereinafter, a sensor module **1** according to a first embodiment of the present disclosure will be described with reference to the drawings. FIG. **1** is an exploded perspective view of the sensor module **1**. In FIG. **1**, the description of adhesive layers G**11***a*, G**11***b*, G**12***a*, and G**12***b* is omitted. FIG. **2** is a perspective view of the sensor module **1** as viewed in a positive direction of a Y axis. FIG. **3** is a view of the piezoelectric sensor **11** as viewed in a negative direction of a Z axis. FIG. **4** is a view of a piezoelectric film **110** as viewed in the negative direction of the Z axis. FIG. **5** is a view of a touch sensor **12** as viewed in the negative direction of the Z axis. FIG. **6** is a view of a plurality of reception electrodes **121**, a plurality of transmission electrodes **122**, and a piezoelectric sensor **11** as viewed in the negative direction of the Z axis. FIG. **7** is a view illustrating a case where a user **200** touches an elastic member **10**.
[0026] In the present embodiment, directions are defined as follows. As illustrated in FIG. **1**, the Z axis direction is a direction in which the elastic member **10**, the piezoelectric sensor **11**, and the touch sensor **12** are arranged. A positive direction of the Z axis is a direction in which the touch sensor **12**, the piezoelectric sensor **11**, and the elastic member **10** are arranged in this order. The negative direction of the Z axis is a direction in which the elastic member **10**, the piezoelectric sensor **11**, and the touch sensor **12** are arranged in this order. An X axis direction is a direction orthogonal to the Z axis direction. A Y axis direction is a direction orthogonal to the Z axis

direction and the X axis direction.

[0027] The sensor module **1** is used in, for example, an electronic device such as a smartphone. As illustrated in FIGS. **1** and **2**, the sensor module **1** includes the elastic member **10**, the piezoelectric sensor **11**, and the touch sensor **12**.

[0028] The elastic member **10** is formed of, for example, resin. As illustrated in FIG. **1**, the elastic member **10** has a plate shape having a long side extending along the X axis and a short side extending along the Y axis. The elastic member **10** has elasticity. The elastic member **10** is deformed by a force applied to the elastic member **10**. For example, the user **200** presses the elastic member **10** in the negative direction of the Z axis. The elastic member **10** is deformed by the force which is applied to the elastic member **10** in the negative direction of the Z axis, so as to protrude in the negative direction of the Z axis.

[0029] As illustrated in FIGS. **1** and **3**, the piezoelectric sensor **11** has a rectangular shape which has a long side extending along the X axis and a short side extending along the Y axis. As illustrated in FIGS. **1** to **3**, the piezoelectric sensor **11** includes the piezoelectric film **110**, a first electrode **111**, a second electrode **112**, a first dielectric layer **113**, the adhesive layer G**11***a*, the adhesive layer G**11***b*, and a detection circuit (not illustrated).

[0030] As illustrated in FIGS. **1** and **4**, the piezoelectric film **110** has a sheet shape which has a long side extending along the X axis and a short side extending along the Y axis. As illustrated in FIGS. **1** and **2**, the piezoelectric film **110** includes a piezoelectric film first main surface SF**1***a* and a piezoelectric film second main surface SF**2***a* arranged along the Z axis. The piezoelectric film first main surface SF**1***a* and the piezoelectric film second main surface SF**2***a* are arranged in this order in the negative direction of the Z axis.

[0031] The piezoelectric film **110** generates a charge according to a deformation amount of the piezoelectric film **110**. A polarity of the charge generated when the piezoelectric film **110** is stretched in the X axis direction is opposite to a polarity of the charge generated when the piezoelectric film **110** is stretched in the Y axis direction. Specifically, the piezoelectric film **110** is a film formed of a chiral polymer. The chiral polymer is, for example, polylactic acid (PLA), particularly poly-L-lactic acid (PLLA). A main chain of the PLLA has a helical structure. The PLLA has piezoelectricity in which molecules are oriented when uniaxial stretching is performed. In the present embodiment, a material of the piezoelectric film **110** is polylactic acid. The piezoelectric film **110** has a piezoelectric constant of d**14**. As illustrated in FIG. **4**, a uniaxial stretching direction OD of the piezoelectric film **110** forms an angle of 45 degrees with respect to the X axis direction and the Y axis direction. The 45 degrees include, for example, an angle including about 45 degrees±10 degrees. As a result, the piezoelectric film **110** generates a charge when the piezoelectric film **110** is stretched in the X axis direction or the Y axis direction. The piezoelectric film **110** generates a positive charge when the piezoelectric film **110** is stretched in the X axis direction, for example. The piezoelectric film **110** generates a negative charge when the piezoelectric film **110** is stretched in the Y axis direction, for example. A magnitude of the charge depends on a differential value of the deformation amount of the piezoelectric film **110** due to stretching or compression.

[0032] The first electrode **111** is a reference electrode connected to a reference potential. The first electrode **111** is located on the positive side of the Z axis with respect to the piezoelectric film **110**. The first electrode **111** is provided on the piezoelectric film first main surface SF**1***a*. The first electrode **111** is fixed to the piezoelectric film first main surface SF**1***a* by an adhesive (not illustrated) such as an optically clear adhesive (OCA). A material of the first electrode **111** is, for example, indium tin oxide (ITO).

[0033] The first electrode **111** includes three types of portions having different shapes. Specifically, as illustrated in FIGS. **1** and **3**, the first electrode **111** includes a plurality of first electrode first portions **111**A, a plurality of first electrode second portions **111**B, and a plurality of first electrode third portions **111**C.

[0034] In the present embodiment, each of the plurality of first electrode first portions **111**A has a square shape as viewed in the Z axis direction. The plurality of first electrode first portions **111**A have the same shape as viewed in the Z axis direction. The plurality of first electrode first portions **111**A are arranged in a matrix on the piezoelectric film first main surface SF**1***a*. Specifically, as illustrated in FIG. **3**, a plurality of sets ST of the plurality of first electrode first portions **111**A arranged along the X axis are provided on the piezoelectric film first main surface SF**1***a*. The plurality of sets are arranged at equal intervals along the Y axis. The plurality of first electrode first portions **111**A are not in contact with each other. The plurality of first electrode first portions **111**A do not overlap each other as viewed in the Z axis direction.

[0035] As illustrated in FIGS. **1** and **3**, each of the plurality of first electrode second portions **111**B extends along the X axis. A length of each of the plurality of first electrode second portions **111**B in the Y axis direction is shorter than a length of each of the plurality of first electrode first portions **111**A in the Y axis direction. As illustrated in FIGS. **1** and **3**, each of the plurality of first electrode second portions **111**B electrically connects two adjacent first electrode first portions **111**A of the plurality of first electrode first portions **111**A arranged along the X axis.

[0036] As illustrated in FIGS. **1** and **3**, each of the plurality of first electrode third portions **111**C extends along the Y axis. Each of the plurality of first electrode third portions **111**C electrically connects two adjacent first electrode first portions **111**A of the plurality of first electrode first portions **111**A arranged along the Y axis. A length of each of the plurality of first electrode third portions **111**C in the X axis direction is shorter than a length of each of the plurality of first electrode first portions **111**A in the X axis direction.

[0037] As illustrated in FIGS. **1** and **2**, the first dielectric layer **113** has a sheet shape which has a long side extending along the X axis and a short side extending along the Y axis. The first dielectric layer **113** is located on the negative side of the Z axis with respect to the piezoelectric film **110**. The first dielectric layer **113** includes a first dielectric layer first main surface SF**1***b* and a first dielectric layer second main surface SF**2***b* arranged along the Z axis. The first dielectric layer first main surface SF**1***b* and the first dielectric layer second main surface SF**2***b* are arranged in this order in the negative direction of the Z axis. The first dielectric layer **113** has dielectric properties. A material of the first dielectric layer **113** is polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polypropylene (PP), or the like.

[0038] The second electrode **112** is a signal electrode. As illustrated in FIGS. **1** and **2**, the second electrode **112** is located on the negative side of the Z axis with respect to the piezoelectric film **110**. The second electrode **112** is provided on the first dielectric layer first main surface SF**1***b*. The second electrode **112** is fixed to the first dielectric layer first main surface SF**1***b* by an adhesive (not illustrated) such as OCA. As illustrated in FIGS. **1** and **3**, the second electrode **112** overlaps the first electrode **111** as viewed in the Z axis direction. A material of the second electrode **112** is, for example, ITO.

[0039] As illustrated in FIGS. **1** and **3**, the second electrode **112** includes three types of portions having different shapes, similarly to the first electrode **111**. The second electrode **112** includes a plurality of second electrode first portions **112**A, a plurality of second electrode second portions **112**B, and a plurality of second electrode third portions **112**C.

[0040] Similarly to the plurality of first electrode first portions **111**A, the plurality of second electrode first portions **112**A are arranged in a matrix on the first dielectric layer first main surface SF**1***b* (see FIGS. **1** and **3**). The plurality of second electrode first portions **112**A overlap the plurality of first electrode first portions **111**A as viewed in the Z axis direction, respectively. The other configuration of each of the plurality of second electrode first portions **112**A is the same as the configuration of the plurality of first electrode first portions **111**A, and thus the description thereof will be omitted.

[0041] Each of the plurality of second electrode second portions **112**B electrically connects two adjacent second electrode first portions **112**A of the plurality of second electrode first portions

112A arranged along the X axis. The plurality of second electrode second portions **112**B overlap the plurality of first electrode second portions **111**B as viewed in the Z axis direction, respectively. The other configuration of each of the plurality of second electrode second portions **112**B is the same as the configuration of the plurality of first electrode second portions **111**B, and thus the description thereof will be omitted.

[0042] Each of the plurality of second electrode third portions **112**C electrically connects two adjacent second electrode first portions **112**A of the plurality of second electrode first portions **112**A arranged along the Y axis. The plurality of second electrode third portions **112**C overlap the plurality of first electrode third portions **111**C as viewed in the Z axis direction, respectively. The other configuration of each of the plurality of second electrode third portions **112**C is the same as the configuration of the plurality of first electrode third portions **111**C, and thus the description thereof will be omitted.

[0043] As illustrated in FIG. **2**, the adhesive layer G**11***a* is located between the elastic member **10** and the piezoelectric film **110**. The adhesive layer G**11***a* is located around the first electrode **111**. The piezoelectric film **110** is fixed to the elastic member **10** by the adhesive layer G**11***a*.

[0044] As illustrated in FIG. **2**, the adhesive layer G**11***b* (first adhesive layer) is located between the first dielectric layer **113** and the piezoelectric film **110**. The adhesive layer G**11***b* is located around the second electrode **112**. The first dielectric layer **113** is fixed to the piezoelectric film **110** by the adhesive layer G**11***b*.

[0045] The detection circuit is electrically connected to the first electrode **111** and the second electrode **112**. The detection circuit converts the charge generated by the piezoelectric film **110** into a voltage signal. The detection circuit AD-converts the voltage signal to generate a first signal which is a digital signal.

[0046] The piezoelectric sensor **11** outputs the first signal corresponding to the deformation of the elastic member **10**. As illustrated in FIG. **1**, the piezoelectric sensor **11** is fixed to the elastic member **10** by the adhesive layer G**11***b*. As a result, the piezoelectric sensor **11** is deformed along with the deformation of the elastic member **10**. The piezoelectric sensor **11** outputs the first signal corresponding to the deformation of the piezoelectric sensor **11**. The piezoelectric sensor **11** outputs the first signal on the basis of a potential difference between the first electrode **111** and the second electrode **112**.

[0047] As illustrated in FIGS. **1** and **5**, the touch sensor **12** has a plate shape which has a long side extending along the X axis and a short side extending along the Y axis. Specifically, the touch sensor **12** is a capacitive touch sensor. As illustrated in FIGS. **1**, **2**, **5**, and **6**, the touch sensor **12** includes a second dielectric layer **120**, a plurality of reception electrodes **121**, a plurality of transmission electrodes **122**, a third dielectric layer **123**, the adhesive layer G**12***a*, the adhesive layer G**12***b*, a transmission circuit **124**, and a reception circuit **125**.

[0048] As illustrated in FIGS. **1** and **5**, the second dielectric layer **120** has a sheet shape which has a long side extending along the X axis and a short side extending along the Y axis. As illustrated in FIG. **2**, the second dielectric layer **120** is located on the negative side of the Z axis with respect to the first dielectric layer **113**. Therefore, the second dielectric layer **120** is located on the negative side of the Z axis with respect to the piezoelectric film **110**. The second dielectric layer **120** includes a second dielectric layer first main surface SF**1***c* and a second dielectric layer second main surface SF**2***c* arranged along the Z axis. The second dielectric layer first main surface SF**1***c* and the second dielectric layer second main surface SF**2***c* are arranged in this order in the negative direction of the Z axis. The other configuration of the second dielectric layer **120** is the same as the configuration of the first dielectric layer **113**, and thus the description thereof will be omitted.

[0049] As illustrated in FIGS. **1** and **2**, each of the plurality of reception electrodes **121** is provided on the second dielectric layer first main surface SF**1***c*. Each of the plurality of reception electrodes **121** is fixed to the second dielectric layer first main surface SF**1***c* by an adhesive (not illustrated) such as OCA. As illustrated in FIG. **5**, each of the plurality of reception electrodes **121** extends along the Y axis. The plurality of reception electrodes **121** are arranged at equal intervals along the X axis. The plurality of reception electrodes **121** are not in contact with each other. The plurality of reception electrodes **121** do not overlap each other as viewed in the Z axis direction. A material of each of the plurality of reception electrodes **121** is, for example, ITO.

[0050] Each of the plurality of reception electrodes **121** includes two types of portions having different shapes. Specifically, each of the plurality of reception electrodes **121** includes a plurality of reception electrode first portions **121**A and a plurality of reception electrode second portions **121**B.

[0051] As illustrated in FIGS. **1** and **5**, each of the plurality of reception electrode first portions **121**A has a square shape as viewed in the Z axis direction. The plurality of reception electrode first portions **121**A have the same shape as viewed in the Z axis direction. Similarly to the plurality of first electrode first portions **111**A, the plurality of reception electrode first portions **121**A are arranged in a matrix on the second dielectric layer first main surface SF**1***c*. In the present embodiment, the plurality of reception electrode first portions **121**A overlap the plurality of first electrode first portions **111**A as viewed in the Z axis direction, respectively (see FIGS. **1**, **2**, and **6**).

[0052] Each of the plurality of reception electrode second portions **121**B extends along the Y axis as illustrated in FIGS. **1** and **5**. A width of each of the plurality of reception electrode second portions **121**B in the X axis direction is shorter than a width of each of the plurality of reception electrodes **121** in the X axis direction. Each of the plurality of reception electrode second portions **121**B electrically connects two adjacent reception electrode first portions **121**A of the plurality of reception electrode first portions **121**A arranged along the Y axis. In the present embodiment, the plurality of reception electrode second portions **121**B overlap the plurality of first electrode second portions **111**B and the plurality of second electrode second portions **112**B as viewed in the Z axis direction, respectively.

[0053] As illustrated in FIG. **2**, the third dielectric layer **123** is located on the negative side of the Z axis with respect to the second dielectric layer **120**. The third dielectric layer **123** includes a third dielectric layer first main surface SF**1***d* and a third dielectric layer second main surface SF**2***d* arranged along the Z axis. The third dielectric layer first main surface SF**1***d* and the third dielectric layer second main surface SF**2***d* are arranged in this order in the negative direction of the Z axis. The other configuration of the third dielectric layer **123** is the same as the configuration of the second dielectric layer **120**, and thus the description thereof will be omitted.

[0054] The plurality of transmission electrodes **122** are located on the negative side of the Z axis with respect to the plurality of reception electrodes **121**. The plurality of transmission electrodes **122** are provided on the third dielectric layer first main surface SF**1***d*. Each of the plurality of transmission electrodes **122** is fixed to the third dielectric layer first main surface SF**1***d* by an adhesive (not illustrated) such as OCA. As illustrated in FIG. **5**, each of the plurality of transmission electrodes **122** extends along the X axis. The plurality of transmission electrodes **122** are arranged at equal intervals in the Y axis direction. The plurality of transmission electrodes **122** is not in contact with each other. The plurality of transmission electrodes **122** do not overlap each other as viewed in the Z axis direction. A material of each of the plurality of transmission electrodes **122** is, for example, ITO.

[0055] Each of the plurality of transmission electrodes **122** includes two types of portions having different shapes. Each of the plurality of transmission electrodes **122** includes a plurality of transmission electrode first portions **122**A and a plurality of transmission electrode second portions **122**B.

[0056] As illustrated in FIG. **5**, each of the plurality of transmission electrode first portions **122**A has a square shape as viewed in the Z axis direction. The plurality of transmission electrode first portions **122**A have the same shape as viewed in the Z axis direction. Similarly to the plurality of first electrode first portions **111**A, the plurality of transmission electrode first portions **122**A are arranged in a matrix on the third dielectric layer **123**. In the present embodiment, each of the plurality of transmission electrode first portions **122**A does not overlap the first electrode **111** and the second electrode **112** as illustrated in FIG. **6**. The plurality of transmission electrode first portions **122**A do not overlap the plurality of reception electrodes **121**.

[0057] Each of the plurality of transmission electrode second portions **122**B has a shape extending along the X axis. A length of each of the plurality of transmission electrode second portions **122**B in the Y axis direction is shorter than a length of each of the plurality of transmission electrode first portions **122**A in the Y axis direction. Each of the plurality of transmission electrode second portions **122**B electrically connects two adjacent transmission electrode first portions **122**A of the plurality of transmission electrode first portions **122**A arranged along the X axis.

[0058] In the present embodiment, as illustrated in FIG. **5**, parts of the plurality of transmission electrode second portions **122**B overlap the plurality of reception electrode second portions **121**B as viewed in the Z axis direction, respectively. More specifically, a center of each of the plurality of transmission electrode second portions **122**B in the X axis direction and a vicinity thereof overlap with the reception electrode second portion **121**B. That is, as illustrated in FIG. **5**, the plurality of transmission electrodes **122** include a plurality of first overlapping portions T**1** overlapping the plurality of reception electrodes **121** as viewed in the Z axis direction. In addition, the plurality of transmission electrodes **122** include a plurality of first non-overlapping portions NT**1** that do not overlap the plurality of reception electrodes **121** as viewed in the Z axis direction. Each of the plurality of first non-overlapping portions NT**1** is a portion other than the plurality of first overlapping portions T**1** in the plurality of transmission electrodes **122**. Therefore, in the example illustrated in FIG. **5**, the plurality of first non-overlapping portions NT**1** includes the plurality of transmission electrode first portions **122**A and both ends of the plurality of transmission electrode second portions **122**B in the X axis direction, respectively.

[0059] In the present embodiment, as illustrated in FIG. **6**, the plurality of first non-overlapping portions NT**1** do not overlap the first electrode **111** and the second electrode **112** as viewed in the Z axis direction. Each of the plurality of transmission electrode first portions **122**A and both ends of each of the plurality of transmission electrode second portions **122**B in the X axis direction do not overlap the first electrode **111** and the second electrode **112** as viewed in the Z axis direction.

[0060] In the above configuration, as illustrated in FIG. **6**, it is sufficient that a center of gravity Gr of each of at least the plurality of transmission electrode first portions **122**A does not overlap the first electrode **111** and the second electrode **112**. Therefore, a portion other than the center of gravity Gr in each of the plurality of transmission electrode first portions **122**A may overlap the first electrode **111** and the second electrode **112**. In the present embodiment, unless otherwise specified, the center of gravity Gr means a center of gravity as viewed in the Z axis direction. Therefore, the center of gravity Gr in the present embodiment is a center of gravity in a two-dimensional plane.

[0061] As illustrated in FIG. **2**, the adhesive layer G**12***a* is located between the first dielectric layer **113** and the second dielectric layer **120**. The second dielectric layer **120** is fixed to the first dielectric layer **113** by the adhesive layer G**12***a*. The adhesive layer G**12***a* is located around the plurality of reception electrodes **121**.

[0062] As illustrated in FIG. **2**, the adhesive layer G**12***b* (second adhesive layer) is located between the second dielectric layer **120** and the third dielectric layer **123**. The third dielectric layer **123** is fixed to the second dielectric layer **120** by the adhesive layer G**12***b*. The adhesive layer G**12***b* is located around the plurality of transmission electrodes **122**.

[0063] The transmission circuit **124** transmits a signal (hereinafter, referred to as a transmission signal) to each of the plurality of transmission electrodes **122**. The transmission circuit **124** is, for example, an electric circuit including a multiplexer. The multiplexer sequentially selects the plurality of transmission electrodes **122** one by one. The transmission circuit **124** transmits a transmission signal to one transmission electrode **122** selected by the multiplexer among the plurality of transmission electrodes **122**.

[0064] The reception circuit **125** receives a signal (hereinafter, referred to as a reception signal) from each of the plurality of reception electrodes **121**. The reception circuit **125** is an electric circuit including a multiplexer. The multiplexer sequentially selects the plurality of reception electrodes **121** one by one. The reception circuit **125** receives the reception signal from one reception electrode **121** selected by the multiplexer among the plurality of reception electrodes **121**. As a result, the touch sensor **12** outputs a second signal on the basis of a capacitance value of a capacitance generated between the plurality of transmission electrodes **122** and the plurality of reception electrodes **121**. The touch sensor **12** transmits the second signal to an arithmetic circuit **13**.
[0065] The arithmetic circuit **13** specifies a position touched by the user **200** on the elastic member **10**, on the basis of the second signal. Specifically, the arithmetic circuit **13** calculates the capacitance value of the capacitance generated between the plurality of transmission electrodes **122** and the plurality of reception electrodes **121**, on the basis of the second signal. The arithmetic circuit **13** specifies the position touched by the user **200** on the elastic member **10**, on the basis of the calculated capacitance value.
[0066] For example, as illustrated in FIG. **2**, when the user **200** does not touch the elastic member **10**, a capacitance having a capacitance value C**1** is generated between one transmission electrode **122** among the plurality of transmission electrodes **122** and one reception electrode **121** among the plurality of reception electrodes **121**. Here, as illustrated in FIG. **7**, the user **200** touches the elastic member **10**. At this time, a capacitance having a capacitance value C**2** is generated between the user **200** and one transmission electrode **122** (hereinafter, referred to as a detection transmission electrode) among the plurality of transmission electrodes **122**. At this time, due to the capacitance generated between the user **200** and the detection transmission electrode, a capacitance having a capacitance value C**3** different from the capacitance value C**1** is generated between one reception electrode **121** (hereinafter, referred to as a detection reception electrode) among the plurality of reception electrodes **121** and the detection transmission electrode. The capacitance value C**3** is less than the capacitance value C**1**. At this time, the arithmetic circuit **13** specifies, as the detection transmission electrode, one transmission electrode **122**, in which the capacitance having the capacitance value C**3** is generated between the transmission electrode **122** and the plurality of reception electrodes **121**, among the plurality of transmission electrodes **122**. In addition, the arithmetic circuit **13** specifies, as the detection reception electrode, one reception electrode **121**, in which the capacitance having the capacitance value C**3** is generated between the reception electrode **121** and the plurality of transmission electrodes **122**, among the plurality of reception electrodes **121**. The arithmetic circuit **13** determines, as the position touched by the user **200** on the elastic member **10**, a position at which the detection transmission electrode and the detection reception electrode intersect as viewed in the Z axis direction.
Advantageous Effect
[0067] According to the sensor module **1**, the piezoelectric sensor **11** can easily detect the deformation of the elastic member **10**. Hereinafter, the sensor module **1** and the touch sensor described in Patent Document 1 will be described in comparison with each other. In the touch sensor described in Patent Document 1, each of the first piezoelectric detection electrode and the second piezoelectric detection electrode has an annular shape as viewed in the thickness direction of the touch sensor. Each of the first piezoelectric detection electrode and the second piezoelectric detection electrode is provided at an outer peripheral edge portion of the plate. Here, in the touch sensor described in Patent Document 1, the outer peripheral end of the plate is fixed to the housing. Therefore, the outer peripheral edge portion of the plate is less likely to be deformed than the center of the press detecting sensor and the vicinity thereof. Therefore, when the user presses the outer peripheral edge portion of the plate, it may be difficult for the press detecting sensor to detect deformation of the plate.
[0068] On the other hand, in the sensor module **1**, a plurality of first electrodes **111** are provided on

the entire surface of the elastic member **10**. Therefore, regardless of the position where the user **200** presses the elastic member **10**, the piezoelectric sensor **11** can easily detect the force applied to the elastic member **10** by the user **200**.

[0069] In the touch sensor described in Patent Document 1, each of the first piezoelectric detection electrode and the second piezoelectric detection electrode has an annular shape as viewed in the thickness direction of the touch sensor. Each of the first piezoelectric detection electrode and the second piezoelectric detection electrode is provided on the outer peripheral edge portion of the plate as viewed in the thickness direction of the touch sensor. Here, in the field of an electronic device such as a smartphone in which the touch sensor described in Patent Document 1 is used, it is desired to reduce a size of the outer peripheral edge portion of the electronic device (to make the electronic device bezel-less). However, when the touch sensor described in Patent Document 1 is made bezel-less, a size of a portion of the touch sensor where the first piezoelectric detection electrode and the second piezoelectric detection electrode are provided is reduced. Therefore, in the bezel-less touch sensor, there is a possibility that a size of each of the first piezoelectric detection electrode and the second piezoelectric detection electrode decreases. As a result, a sensitivity of the touch sensor may decrease.

[0070] On the other hand, in the sensor module **1**, a plurality of first electrodes **111** are provided at both the center of the elastic member **10** and the vicinity thereof and the outer peripheral edge portion of the elastic member **10**. Therefore, when the electronic device including the sensor module **1** is made bezel-less, the sensitivity of the touch sensor **12** is less likely to decrease as compared with the smartphone including the touch sensor described in Patent Document 1.

[0071] Hereinafter, a sensor module (hereinafter, referred to as Comparative Example 1) in which the piezoelectric sensor is located on the negative side of the Z axis with respect to the touch sensor and the sensor module **1** will be described in comparison with each other. In Comparative Example 1, when the user presses the elastic member, the force applied to the elastic member is transmitted to the piezoelectric sensor via the touch sensor. Therefore, in Comparative Example 1, since the piezoelectric sensor is located on the negative side of the Z axis with respect to the touch sensor, a force is less likely to be applied to the piezoelectric sensor. Therefore, it is difficult for the piezoelectric sensor to detect the deformation of the elastic member.

[0072] On the other hand, in the sensor module **1**, the piezoelectric sensor **11** is located on the positive side of the Z axis with respect to the touch sensor **12**. In this case, as compared with Comparative Example 1, the force applied to the elastic member **10** is easily transmitted to the piezoelectric sensor **11**. Therefore, the piezoelectric sensor **11** is likely to be deformed by the force applied to the elastic member **10**. As a result, the piezoelectric sensor **11** can easily detect the deformation of the elastic member **10**.

[0073] In the sensor module **1**, the piezoelectric sensor **11** is located on the positive side of the Z axis with respect to the touch sensor **12**. In this case, a distance between the plurality of transmission electrodes **122** and the second electrode **112** in the sensor module **1** is longer than a distance between the plurality of transmission electrodes and the first electrodes in Comparative Example 1. Therefore, noise is less likely to be generated in the plurality of transmission electrodes **122** in the sensor module **1**, as compared with the plurality of transmission electrodes in Comparative Example 1. Therefore, an area of the plurality of transmission electrodes **122** can be increased. As a result, the sensitivity of the touch sensor **12** is improved.

[0074] In the sensor module **1**, the plurality of first non-overlapping portions NT**1** do not overlap the plurality of reception electrodes **121** as viewed in the Z axis direction. In this case, as illustrated in FIG. **5**, an electric field generated by the transmission electrode **122** is less likely to be shielded by the plurality of reception electrodes **121**. In addition, the plurality of first non-overlapping portions NT**1** do not overlap the first electrode **111** and the second electrode **112**. In this case, as illustrated in FIG. **5**, the electric field generated by the transmission electrode **122** is less likely to be shielded by the plurality of reception electrodes **121**, the first electrode **111**, or the second electrode **112**. Therefore, a capacitance is easily generated between each of the plurality of transmission electrodes **122** and the user **200**. As a result, the arithmetic circuit **13** can easily specify the position touched by the user **200** on the elastic member **10**.

[0075] In the sensor module **1**, the plurality of first non-overlapping portions NT**1** do not overlap the first electrode **111** and the second electrode **112**. In this case, each of the first electrode **111** and the second electrode **112** is less likely to be affected by the noise generated by the plurality of transmission electrodes **122**.

[0076] In the sensor module **1**, each of the plurality of reception electrodes **121** overlaps the first electrode **111** and the second electrode **112**. In this case, a magnetic field generated in the first electrode **111** and the second electrode **112** is easily shielded by the plurality of reception electrodes **121**. As a result, each of the plurality of transmission electrodes **122** is less likely to be affected by the noise generated by the first electrode **111** and the second electrode **112**.

[Other Configurations of Sensor Module **1**]

[0077] Hereinafter, other configurations of the sensor module **1** will be described with reference to FIGS. **1** to **7**.

[0078] The plurality of reception electrodes **121** include a plurality of second non-overlapping portions NT**2** that do not overlap the plurality of transmission electrodes **122** as viewed in the Z axis direction (see FIG. **5**). The plurality of second non-overlapping portions NT**2** do not overlap the plurality of first non-overlapping portions NT**1** and the plurality of first overlapping portions T**1**.

[0079] The plurality of reception electrodes **121** includes a plurality of second overlapping portions T**2** overlapping the plurality of transmission electrodes **122** as viewed in the Z axis direction. The plurality of second overlapping portions T**2** overlap the plurality of first overlapping portions T**1**, respectively. The plurality of second overlapping portions T**2** do not overlap the plurality of first non-overlapping portions NT**1**, respectively. In the present embodiment, the plurality of reception electrodes **121** overlap the first electrode **111** and the second electrode **112** as viewed in the Z axis direction. Therefore, the plurality of second non-overlapping portions NT**2** and the plurality of second overlapping portions T**2** overlap the first electrode **111** and the second electrode **112** as viewed in the Z axis direction.

[First Modification]

[0080] Hereinafter, a sensor module **1***a* according to a first modification will be described with reference to the drawings. FIG. **8** is a view illustrating the sensor module **1***a* according to the first modification. FIG. **9** is a view illustrating a case where the user **200** touches the elastic member **10** included in the sensor module **1***a*.

[0081] The sensor module **1***a* is different from the sensor module **1** in that a part of the plurality of reception electrodes **121** does not overlap the first electrode **111** and the second electrode **112**. Specifically, as illustrated in FIG. **8**, the plurality of second non-overlapping portions NT**2** do not overlap a plurality of first electrodes **111** and a plurality of second electrodes **112** as viewed in the Z axis direction. In the above configuration, similarly to the sensor module **1**, the electric field generated by the plurality of transmission electrodes **122** is less likely to be shielded by the plurality of reception electrodes **121** as illustrated in FIG. **9**. As a result, the touch sensor **12** in the sensor module **1***a* can easily specify the position touched by the user **200** on the elastic member **10**.

[0082] In addition, the sensor module **1***a* is different from the sensor module **1** in that the plurality of transmission electrodes **122** overlap the first electrode **111** and the second electrode **112**. Specifically, the plurality of first overlapping portions T**1** overlap the first electrode **111** and the second electrode **112**. The plurality of first non-overlapping portions NT**1** overlap the first electrode **111** and the second electrode **112**.

[0083] Similarly to the sensor module **1**, in the sensor module **1***a*, the plurality of transmission electrodes **122** are located on the negative side of the Z axis with respect to the plurality of reception electrodes **121**, and the plurality of second electrodes **112** are located on the positive side of the Z axis with respect to the plurality of reception electrodes **121**. That is, the plurality of transmission electrodes **122** are not close to the second electrode **112** (see FIG. **9**). As a result, the electric field generated by the plurality of transmission electrodes **122** is less likely to be shielded by the second electrode **112**.

[0084] Such a sensor module **1***a* has an effect similar to that of the sensor module **1**.

[Second Modification]

[0085] Hereinafter, a sensor module **1***b* according to a second modification will be described with reference to the drawings. FIG. **10** is a diagram illustrating the sensor module **1***b* according to the second modification.

[0086] The sensor module **1***b* is different from the sensor module **1** in that the sensor module **1***b* includes a touch sensor **12***b* instead of the touch sensor **12**. The touch sensor **12***b* is different from the touch sensor **12** in that the touch sensor **12***b* includes a plurality of reception electrodes **121***b* instead of the plurality of reception electrodes **121** and includes a plurality of transmission electrodes **122***b* instead of the plurality of transmission electrodes **122**.

[0087] A shape of each of the plurality of reception electrodes **121***b* is different from the shape of each of the plurality of reception electrodes **121**. Each of the plurality of reception electrodes **121***b* has a rectangular shape extending in the Y axis direction. A width of each of the plurality of reception electrodes **121***b* in the X axis direction is constant.

[0088] A shape of each of the plurality of transmission electrodes **122***b* is different from the shape of each of the plurality of transmission electrodes **122**. Each of the plurality of transmission electrodes **122***b* has a rectangular shape extending in the X axis direction. A width of each of the plurality of reception electrodes **121***b* in the Y axis direction is constant. Similarly to the plurality of transmission electrodes **122**, each of the plurality of transmission electrodes **122***b* has the plurality of first non-overlapping portions NT**1** (see FIG. **10**). As viewed in the Z axis direction, the plurality of first non-overlapping portions NT**1** are located between two adjacent reception electrodes **121***b* among the plurality of reception electrodes **121***b*. In the present modification, the plurality of first non-overlapping portions NT**1** each have a rectangular shape as viewed in the Z axis direction.

[0089] Such a sensor module **1***b* has an effect similar to that of the sensor module **1**.

[Third Modification]

[0090] Hereinafter, a sensor module **1***c* according to a third modification will be described with reference to the drawings. FIG. **11** is a view illustrating the sensor module **1***c* according to the third modification.

[0091] The sensor module **1***c* is different from the sensor module **1** in that the sensor module **1***c* includes a piezoelectric sensor **11***c* instead of the piezoelectric sensor **11**. The piezoelectric sensor **11***c* is different from the piezoelectric sensor **11** in that the piezoelectric sensor **11***c* includes a plurality of first electrodes **1110** to **1115** and a plurality of second electrodes **1120** to **1125**.

[0092] The plurality of first electrodes **1110** to **1115** are arranged in a matrix in the piezoelectric film **110**. The plurality of first electrodes **1110** to **1115** are not electrically connected to each other. Each of the plurality of first electrodes **1110** to **1115** is electrically connected to the arithmetic circuit **13** by a wiring member.

[0093] The plurality of second electrodes **1120** to **1125** are arranged in a matrix in the first dielectric layer **113**. The plurality of second electrodes **1120** to **1125** are not electrically connected to each other. Each of the plurality of second electrodes **1120** to **1125** is electrically connected to the arithmetic circuit **13** by a wiring member. The plurality of second electrodes **1120** to **1125** overlap the plurality of first electrodes **1110** to **1115** as viewed in the Z axis direction, respectively.

[0094] Since the plurality of first electrodes **1110** to **1115** and the plurality of second electrodes **1120** to **1125** are provided on the piezoelectric film **110**, the arithmetic circuit **13** receives a plurality of first signals from the piezoelectric sensor **11***c*. That is, the output of the piezoelectric sensor **11***c* is multi-channelized. As a result, the arithmetic circuit **13** can accurately obtain details of an in-plane distribution of the sensitivity of the piezoelectric sensor **11***c*.

[First Modification of Piezoelectric Sensor **11***c*]

[0095] Hereinafter, a piezoelectric sensor **11***d* according to a first modification of the piezoelectric sensor **11***c* will be described with reference to the drawings. FIG. **12** is a view illustrating the piezoelectric sensor **11***d* according to the first modification of the piezoelectric sensor **11***c*.

[0096] As illustrated in FIG. **12**, the piezoelectric sensor **11***d* includes the plurality of first electrodes **1110** to **1114** and the plurality of second electrodes **1120** to **1124**. The first electrode **1110** to the first electrode **1113** and the second electrodes **1120** to **1123** are provided at four corner portions of the piezoelectric film **110** as viewed in the Z axis direction, respectively. The first electrode **1114** and the second electrode **1124** are provided at the center of the piezoelectric film **110** and in the vicinity thereof.

[0097] In the present modification, for example, the number of the plurality of first electrode first portions **111**A included in the first electrode **1114** is less than the number of the plurality of first electrode first portions **111**A included in the first electrode **1110**, **1111**, **1112**, or **1113**. In this case, as viewed in the Z axis direction, a size of the first electrode **1114** (first central electrode), which is provided at the center of the piezoelectric film **110**, among the plurality of first electrodes **1110** to **1114** is smaller than a size of each of the plurality of first electrodes **1110** to **1113**, which are provided around the first electrode **1114** (first central electrode), among the plurality of first electrodes **1110** to **1114**. In the present modification, the size of the first electrode **1110** is specifically a size of a region surrounded by the outer peripheral end of the first electrode **1110** as viewed in the Z axis direction. The same applies to the definition of the size of each of the first electrodes **1111** to **1114**. In the example illustrated in FIG. **12**, the first electrodes **1110** to **1113** are provided near an outer periphery of the piezoelectric film **110** as viewed in the Z axis direction. Therefore, in the example illustrated in FIG. **12**, as viewed in the Z axis direction, the size of the first electrode **1114** provided at the center of the piezoelectric film **110** is less than the size of each of the plurality of first electrodes **1110** to **1113** provided near the outer periphery of the piezoelectric film **110**.

[0098] Similarly, in the present modification, as viewed in the Z axis direction, a size of second electrode **1124** (second central electrode), which is provided at the center of the piezoelectric film **110**, among the plurality of the second electrodes **1120** to **1124** is smaller than a size of each of the plurality of second electrodes **1120** to **1123**, which are provided around the second electrode **1124** (second central electrode), among the plurality of second electrodes **1120** to **1124**.

[0099] A vicinity of an outer periphery of the elastic member **10** is less likely to be deformed than the center of the elastic member **10**. Here, in the present modification, since the plurality of first electrodes **1110** to **1114** and the plurality of second electrodes **1120** to **1124** are provided near the outer periphery of the piezoelectric film **110**, the piezoelectric sensor **11***d* easily detects deformation in the vicinity of the outer periphery of the elastic member **10**. In the present modification, the in-plane distribution of the sensitivity of the piezoelectric sensor **11***d* can be made uniform by adjusting the size of each of the plurality of first electrodes **1110** to **1115** and the size of each of the plurality of second electrodes **1120** to **1125**. That is, the in-plane distribution of the sensitivity of the piezoelectric sensor **11***d* can be made uniform by adjusting the number of the first electrode first portions **111**A included in each of the plurality of first electrodes **1110** to **1115** and the number of the second electrode first portions **112**A included in each of the plurality of second electrodes **1120** to **1125**.

[0100] Note that the in-plane distribution of the sensitivity may be adjusted by adjusting the size of each of the plurality of first electrodes **1110** to **1114**. Note that the in-plane distribution of the sensitivity may be adjusted by adjusting the size of each of the plurality of second electrodes **1120** to **1124**.

[0101] Note that the in-plane distribution of the sensitivity may be adjusted by adjusting the size of each of the plurality of first electrode first portions in the plurality of first electrodes **1110** to **1114**.

Note that the in-plane distribution of the sensitivity may be adjusted by adjusting the size of each of the plurality of second electrode first portions in the plurality of second electrodes **1120** to **1124**.

[Second Modification of Piezoelectric Sensor **11***c*]

[0102] Hereinafter, a piezoelectric sensor **11***e* according to a second modification of the piezoelectric sensor **11***c* will be described with reference to the drawings. FIG. **13** is a view illustrating the piezoelectric sensor **11***e* according to the second modification of the piezoelectric sensor **11***c*.

[0103] In the present modification, the piezoelectric sensor **11***e* includes a piezoelectric film **110***e* instead of the piezoelectric film **110**. As illustrated in FIG. **13**, a uniaxial stretching direction ODe of the piezoelectric film **110***e* forms an angle of 0 degrees or 180 degrees with respect to the Y axis direction.

[0104] In the present modification, the piezoelectric sensor **11***e* includes the plurality of first electrodes **1110** to **1113** and the plurality of second electrodes **1120** to **1123**. The plurality of first electrodes **1110** to **1113** and the plurality of second electrodes **1120** to **1123** are provided near four corners of the piezoelectric film **110** as viewed in the Z axis direction. In this case, the arithmetic circuit **13** can calculate a magnitude, load, and the like of the force applied to each of the four corner portions of the piezoelectric film **110**.

[Touch Panel TP]

[0105] Hereinafter, a touch panel TP including the sensor module **1** will be described with reference to the drawings. FIG. **14** is a view illustrating the touch panel TP including the sensor module **1**.

[0106] As illustrated in FIG. **14**, the touch panel TP includes the sensor module **1** and the arithmetic circuit **13**. The sensor module **1** in the touch panel TP includes the piezoelectric sensor **11**, the touch sensor **12**, and a front panel **10***a*. The front panel **10***a* corresponds to an elastic member in the present application. The configurations of the piezoelectric sensor **11**, the touch sensor **12**, and the arithmetic circuit **13** in the touch panel TP are the same as the configurations of the piezoelectric sensor **11**, the touch sensor **12**, and the arithmetic circuit **13** described in the first embodiment, and thus the description thereof will be omitted.

[0107] Note that the touch panel TP may include the sensor module **1***a* to **1***c* instead of the sensor module **1**.

Example of Electronic Device

[0108] Hereinafter, a smartphone SP including the touch panel TP will be described with reference to the drawings. FIG. **15** is a view illustrating the smartphone SP including the touch panel TP.

[0109] The smartphone SP is an example of the electronic device in the present application. As illustrated in FIG. **15**, the smartphone SP includes the touch panel TP, a housing **2**, and a display **3**. The front panel **10***a*, the piezoelectric sensor **11**, the touch sensor **12**, the arithmetic circuit **13**, and the display **3** are arranged in the housing **2**. The front panel **10***a* is arranged on the outer peripheral edge portion of the housing **2** so as to close an opening surface of the housing **2**. The display **3** is, for example, a liquid crystal display or an organic EL display. The display **3** is arranged, for example, between the front panel **10***a* and the piezoelectric sensor **11**. Note that, in FIG. **15**, the arithmetic circuit **13** is arranged on a bottom surface portion of the housing **2**, but does not necessarily have to be arranged on the bottom surface portion of the housing **2**.

[0110] Note that the electronic device in the present application does not necessarily have to be a smartphone, and may be, for example, a tablet computer.

Other Embodiments

[0111] The sensor module according to the present disclosure is not limited to the sensor modules **1** and **1***a* to **1***c*, and can be modified within the scope of the gist thereof. The configurations of the sensor modules **1** and **1***a* to **1***c* may be arbitrarily combined.

[0112] Note that each of the plurality of first electrode first portions **111**A does not necessarily have to have a square shape as viewed in the Z axis direction. Note that each of the plurality of second electrode first portions **112**A does not necessarily have to have a square shape as viewed in the Z axis direction. Note that each of the plurality of reception electrode first portions **121**A does not necessarily have to have a square shape as viewed in the Z axis direction. Note that each of the plurality of transmission electrode first portions **122**A does not necessarily have to have a square shape as viewed in the Z axis direction.

[0113] Note that the piezoelectric sensor **11** does not necessarily have to include the first dielectric layer **113**. In this case, each of the plurality of second electrodes **112** is provided on the piezoelectric film second main surface SF**2***a*.

[0114] Note that the touch sensor **12** does not necessarily have to include the third dielectric layer **123**. In this case, each of the plurality of reception electrodes **121** and each of the plurality of transmission electrodes **122** are provided on the second dielectric layer second main surface SF**2***c*.

[0115] Note that in the piezoelectric sensor **11***c*, the number of the first electrode first portions **111**A included in each of the plurality of first electrodes **1110** to **1115** does not necessarily have to be six. Note that in the piezoelectric sensor **11***c*, the number of the second electrode first portions **112**A included in each of the plurality of second electrodes **1120** to **1125** does not necessarily have to be six.

[0116] Note that in the piezoelectric sensor **11***d* or the piezoelectric sensor **11***e*, the number of the first electrode first portions **111**A included in each of the plurality of first electrodes **1110** to **1114** does not necessarily have to be nine. In the piezoelectric sensor **11***d*, the number of the second electrode first portions **112**A included in each of the plurality of second electrodes **1120** to **1124** does not necessarily have to be nine.

[0117] Note that in the piezoelectric sensor **11***d*, the number of the first electrode first portions **111**A included in the first electrode **1114** does not necessarily have to be six. In the piezoelectric sensor **11***d*, the number of the second electrode first portions **112**A included in the second electrode **1124** does not necessarily have to be six.

[0118] Note that the sensor module **1**, **1***a* to **1***c* may have a structure in which the plurality of first non-overlapping portions NT**1** do not overlap one or more first electrodes **111** and one or more second electrodes **112** as viewed in the Z axis direction, and a structure in which the plurality of second non-overlapping portions NT**2** do not overlap one or more first electrodes **111** and one or more second electrodes **112** as viewed in the Z axis direction.

[0119] Note that in the sensor module **1***c*, the plurality of first non-overlapping portions NT**1** do not overlap the plurality of first electrodes **1110** to **1115** and the plurality of second electrodes **1120** to **1125** as viewed in the Z axis direction. The same applies to the sensor module **1***c* including the piezoelectric sensor **11***d* or the piezoelectric sensor **11***e*.

[0120] Note that in the sensor module **1***c*, the plurality of second non-overlapping portions NT**2** may not overlap the plurality of first electrodes **1110** to **1115** and the plurality of second electrodes **1120** to **1125** as viewed in the Z axis direction. The same applies to the sensor module **1***c* including the piezoelectric sensor **11***d* or the piezoelectric sensor **11***e*.

[0121] The present disclosure has the following structures.

[0122] (1) A sensor module including: an elastic member; a piezoelectric sensor which includes a piezoelectric film, one or more first electrodes, and one or more second electrodes; and a touch sensor which includes a plurality of transmission electrodes and a plurality of reception electrodes, in which the elastic member, the piezoelectric sensor, and the touch sensor are arranged in this order in a negative direction of a Z axis, each of the one or more first electrodes are on a positive side of the Z axis with respect to the piezoelectric film, each of the one or more second electrodes are on a negative side of the Z axis with respect to the piezoelectric film, the piezoelectric sensor is constructed to output a first signal when the elastic member is deformed, each of the plurality of transmission electrodes are on the negative side of the Z axis with respect to the plurality of reception electrodes, the touch sensor is constructed to output a second signal on the basis of a capacitance value when a capacitance is generated between the plurality of transmission electrodes and the plurality of reception electrodes, the plurality of transmission electrodes include a plurality of first non-overlapping portions that do not overlap the plurality of reception electrodes as viewed in a Z axis direction, the plurality of reception electrodes include a plurality of second non-overlapping portions that do not overlap the plurality of transmission electrodes as viewed in the Z axis direction, and the plurality of first non-overlapping portions or the plurality of second non-overlapping portions do not overlap the one or more first electrodes and the one or more second electrodes as viewed in the Z axis direction.

[0123] (2) The sensor module according to (1), in which the touch sensor further includes a transmission circuit and a reception circuit, the transmission circuit is constructed to transmit a signal to each of the plurality of transmission electrodes, and the reception circuit is constructed to receive signals from the plurality of reception electrodes.

[0124] (3) The sensor module according to (1) or (2), in which the piezoelectric film includes a piezoelectric film first main surface and a piezoelectric film second main surface, the piezoelectric film first main surface and the piezoelectric film second main surface are arranged in this order in the negative direction of the Z axis, and each of the one or more first electrodes are on the piezoelectric film first main surface.

[0125] (4) The sensor module according to (3), in which each of the one or more second electrodes are on the piezoelectric film second main surface.

[0126] (5) The sensor module according to any one of (1) to (3), in which the piezoelectric sensor further includes a first dielectric layer, the first dielectric layer is on the negative side of the Z axis with respect to the piezoelectric film, the first dielectric layer includes a first dielectric layer first main surface and a first dielectric layer second main surface arranged along the Z axis, the first dielectric layer first main surface and the first dielectric layer second main surface are arranged in this order in the negative direction of the Z axis, and each of the plurality of second electrodes are on the first dielectric layer first main surface.

[0127] (6) The sensor module according to (5), in which the piezoelectric sensor further includes a first adhesive layer, the first adhesive layer is between the first dielectric layer and the piezoelectric film, and the first dielectric layer is fixed to the piezoelectric film by the first adhesive layer.

[0128] (7) The sensor module according to any one of (1) to (6), in which the touch sensor further includes a second dielectric layer, the second dielectric layer is on the negative side of the Z axis with respect to the piezoelectric film, the second dielectric layer includes a second dielectric layer first main surface and a second dielectric layer second main surface arranged along the Z axis, the second dielectric layer first main surface and the second dielectric layer second main surface are arranged in this order in the negative direction of the Z axis, and each of the plurality of reception electrodes are on the second dielectric layer first main surface.

[0129] (8) The sensor module according to (7), in which each of the plurality of transmission electrodes are on the second dielectric layer second main surface.

[0130] (9) The sensor module according to (7), in which the touch sensor further includes a third dielectric layer, the third dielectric layer is on the negative side of the Z axis with respect to the second dielectric layer, the third dielectric layer includes a third dielectric layer first main surface and a third dielectric layer second main surface arranged along the Z axis, the third dielectric layer first main surface and the third dielectric layer second main surface are arranged in this order in the negative direction of the Z axis, and each of the plurality of transmission electrodes are on the third dielectric layer first main surface.

[0131] (10) The sensor module according to (9), in which the touch sensor further includes a second adhesive layer, the second adhesive layer is between the second dielectric layer and the third dielectric layer, and the third dielectric layer is fixed to the second dielectric layer by the second adhesive layer.

[0132] (11) The sensor module according to any one of (1) to (10), in which the piezoelectric sensor includes a plurality of the first electrodes and a plurality of the second electrodes, the

plurality of first electrodes as viewed in the Z axis direction includes a first central electrode at a center of the piezoelectric film, the plurality of second electrodes as viewed in the Z axis direction includes a second central electrode at the center of the piezoelectric film, as viewed in the Z axis direction and among the plurality of first electrodes, a size of the first central electrode is smaller than a size of each of the plurality of first electrodes around the first central electrode, and as viewed in the Z axis direction and among the plurality of second electrodes, a size of the second central electrode is smaller than a size of each of the plurality of second electrodes around the second central electrode.
[0133] (12) The sensor module according to any one of (1) to (11), in which a material of the piezoelectric film is polylactic acid.
DESCRIPTION OF REFERENCE SYMBOLS
[0134] **1**, **1***a* to **1***c*:: Sensor module [0135] **10**:: Elastic member [0136] **11**, **11***c* to **11***e*:: Piezoelectric sensor [0137] **110**, **110***e*:: Piezoelectric film [0138] **111**, **1110** to **1115**:: First electrode [0139] **112**, **1120** to **1125**:: Second electrode [0140] **12**, **12***b*:: Touch sensor [0141] **121**, **121***b*:: Reception electrode [0142] **122**, **122***b*:: Transmission electrode [0143] NT**1**:: First non-overlapping portion [0144] NT**2**:: Second non-overlapping portion [0145] TP:: Touch panel [0146] SP:: Smartphone

Claims

1. A sensor module comprising: an elastic member; a piezoelectric sensor which includes a piezoelectric film, one or more first electrodes, and one or more second electrodes; and a touch sensor which includes a plurality of transmission electrodes and a plurality of reception electrodes, wherein the elastic member, the piezoelectric sensor, and the touch sensor are arranged in this order in a negative direction of a Z axis, each of the one or more first electrodes are on a positive side of the Z axis with respect to the piezoelectric film, each of the one or more second electrodes are on a negative side of the Z axis with respect to the piezoelectric film, the piezoelectric sensor is constructed to output a first signal when the elastic member is deformed, each of the plurality of transmission electrodes are on the negative side of the Z axis with respect to the plurality of reception electrodes, the touch sensor is constructed to output a second signal on a basis of a capacitance value when a capacitance is generated between the plurality of transmission electrodes and the plurality of reception electrodes, the plurality of transmission electrodes include a plurality of first non-overlapping portions that do not overlap the plurality of reception electrodes as viewed in a Z axis direction, the plurality of reception electrodes include a plurality of second non-overlapping portions that do not overlap the plurality of transmission electrodes as viewed in the Z axis direction, and the plurality of first non-overlapping portions or the plurality of second non-overlapping portions do not overlap the one or more first electrodes and the one or more second electrodes as viewed in the Z axis direction.
2. The sensor module according to claim 1, wherein the plurality of second non-overlapping portions do not overlap the one or more first electrodes and the one or more second electrodes as viewed in the Z axis direction.
3. The sensor module according to claim 1, wherein the plurality of first non-overlapping portions do not overlap the one or more first electrodes and the one or more second electrodes as viewed in the Z axis direction.
4. The sensor module according to claim 1, wherein the touch sensor further includes a transmission circuit and a reception circuit, the transmission circuit is constructed to transmit a signal to each of the plurality of transmission electrodes, and the reception circuit is constructed to receive signals from the plurality of reception electrodes.
5. The sensor module according to claim 1, wherein the piezoelectric film includes a piezoelectric film first main surface and a piezoelectric film second main surface arranged along the Z axis, the piezoelectric film first main surface and the piezoelectric film second main surface are arranged in

this order in the negative direction of the Z axis, and each of the one or more first electrodes are on the piezoelectric film first main surface.
6. The sensor module according to claim 5, wherein each of the one or more second electrodes are on the piezoelectric film second main surface.
7. The sensor module according to claim 1, wherein the piezoelectric sensor further includes a first dielectric layer, the first dielectric layer is on the negative side of the Z axis with respect to the piezoelectric film, the first dielectric layer includes a first dielectric layer first main surface and a first dielectric layer second main surface arranged along the Z axis, the first dielectric layer first main surface and the first dielectric layer second main surface are arranged in this order in the negative direction of the Z axis, and each of the plurality of second electrodes are on the first dielectric layer first main surface.
8. The sensor module according to claim 7, wherein the piezoelectric sensor further includes a first adhesive layer, the first adhesive layer is between the first dielectric layer and the piezoelectric film, and the first dielectric layer is fixed to the piezoelectric film by the first adhesive layer.
9. The sensor module according to claim 1, wherein the touch sensor further includes a second dielectric layer, the second dielectric layer is on the negative side of the Z axis with respect to the piezoelectric film, the second dielectric layer includes a second dielectric layer first main surface and a second dielectric layer second main surface arranged along the Z axis, the second dielectric layer first main surface and the second dielectric layer second main surface are arranged in this order in the negative direction of the Z axis, and each of the plurality of reception electrodes are on the second dielectric layer first main surface.
10. The sensor module according to claim 9, wherein each of the plurality of transmission electrodes are on the second dielectric layer second main surface.
11. The sensor module according to claim 9, wherein the touch sensor further includes a third dielectric layer, the third dielectric layer is on the negative side of the Z axis with respect to the second dielectric layer, the third dielectric layer includes a third dielectric layer first main surface and a third dielectric layer second main surface arranged along the Z axis, the third dielectric layer first main surface and the third dielectric layer second main surface are arranged in this order in the negative direction of the Z axis, and each of the plurality of transmission electrodes are on the third dielectric layer first main surface.
12. The sensor module according to claim 11, wherein the touch sensor further includes a second adhesive layer, the second adhesive layer is between the second dielectric layer and the third dielectric layer, and the third dielectric layer is fixed to the second dielectric layer by the second adhesive layer.
13. The sensor module according to claim 1, wherein the piezoelectric sensor includes a plurality of the first electrodes and a plurality of the second electrodes, the plurality of first electrodes as viewed in the Z axis direction includes a first central electrode at a center of the piezoelectric film, the plurality of second electrodes as viewed in the Z axis direction includes a second central electrode at the center of the piezoelectric film, as viewed in the Z axis direction and among the plurality of first electrodes, a size of the first central electrode is smaller than a size of each of the plurality of first electrodes around the first central electrode, and as viewed in the Z axis direction and among the plurality of second electrodes, a size of the second central electrode is smaller than a size of each of the plurality of second electrodes around the second central electrode.
14. The sensor module according to claim 1, wherein each of the plurality of reception electrodes has a rectangular shape extending in a Y axis direction, and each of the plurality of transmission electrodes has a rectangular shape extending in an X axis direction.
15. The sensor module according to claim 1, wherein the piezoelectric sensor includes a plurality of the first electrodes and a plurality of the second electrodes, the plurality of first electrodes are arranged in a matrix and not electrically connected to each other, and the plurality of second electrodes are arranged in a matrix and not electrically connected to each other.

16. The sensor module according to claim 1, wherein the piezoelectric sensor includes a plurality of the first electrodes and a plurality of the second electrodes in corners of the piezoelectric film as viewed in the Z axis direction, and a uniaxial stretching direction of the piezoelectric film forms an angle of 0 degrees or 180 degrees with respect to a Y axis direction.
17. The sensor module according to claim 1, wherein a material of the piezoelectric film is polylactic acid.
18. A touch panel comprising the sensor module according to claim 1.
19. An electronic device comprising: the touch panel according to claim **18**.