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(54) **PIEZOELECTRIC VIBRATING PIECE AND PIEZOELECTRIC DEVICE**

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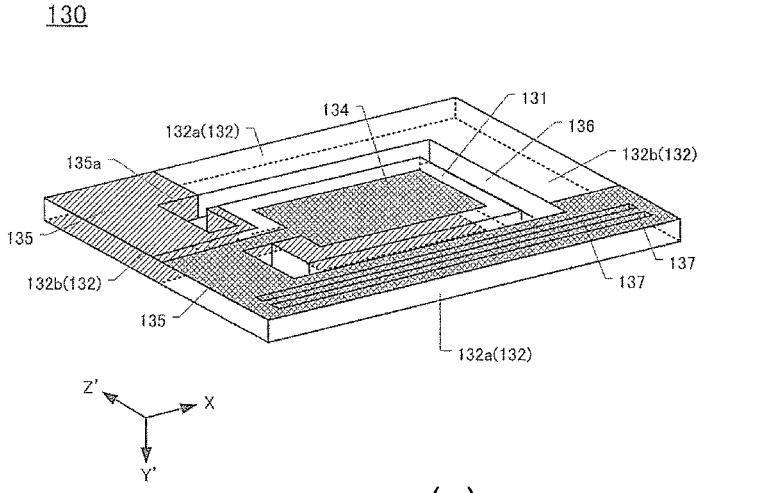
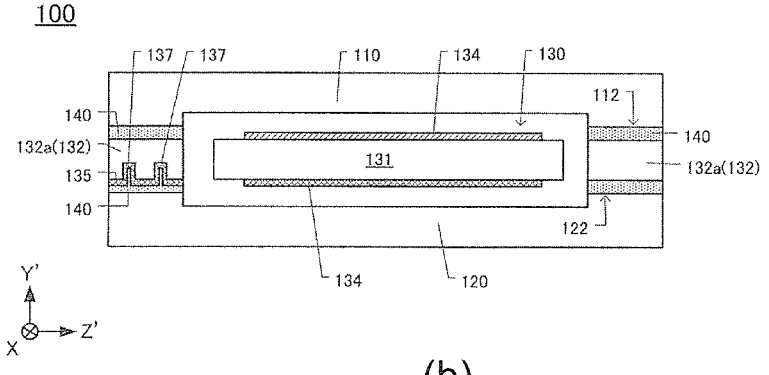
USPC **310/348**

(57) **ABSTRACT**

A piezoelectric vibrating piece includes a rectangular vibrator, a framing portion, and a connecting portion. The rectangular vibrator is configured to vibrate at a predetermined vibration frequency and includes excitation electrodes on both principal surfaces. The framing portion surrounds a peripheral area of the vibrator and includes a first framing body and a second framing body. The first framing body extends in a long side direction. The second framing body extends in a short side direction. The connecting portion connects the vibrator and the framing portion. The first framing body includes a depressed portion or an extruding part on one principal surface that extends in a long side direction. The piezoelectric vibrating piece further includes an extraction electrode extending from the excitation electrode via the connecting portion. The extraction electrode extends from one end to another end of the one principal surface of the first framing body.



(a)



(b)

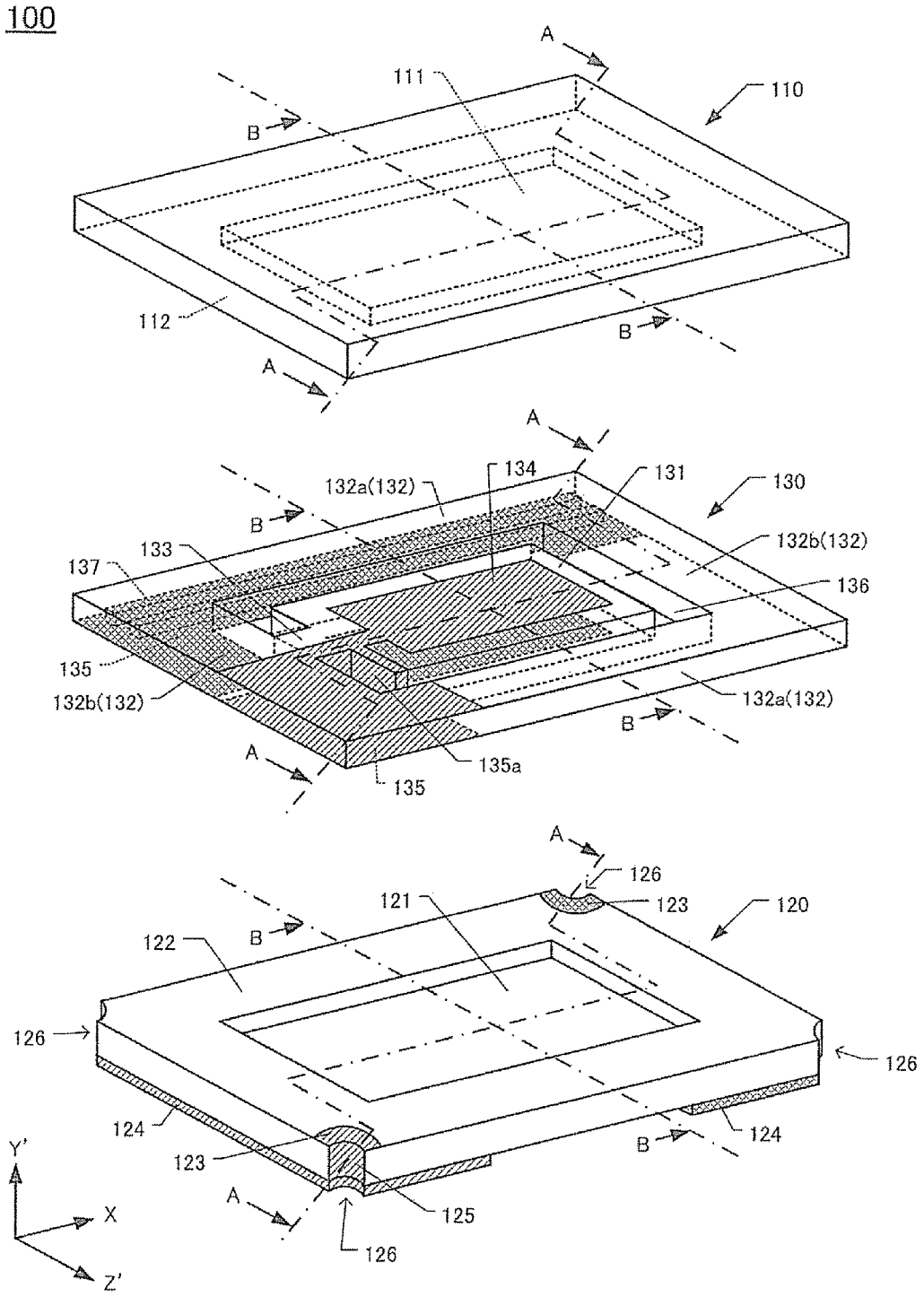

100
A
111
110
B
112
A
B
A
132a(132)
134
131
130
B
133
132b(132)
137
136
135
132b(132)
132a(132)
B
A
135a
135
A
126
121
123
120
122
B
126
126
124
124
123
B
Y'
A
X
125
126
Z'

FIG.1

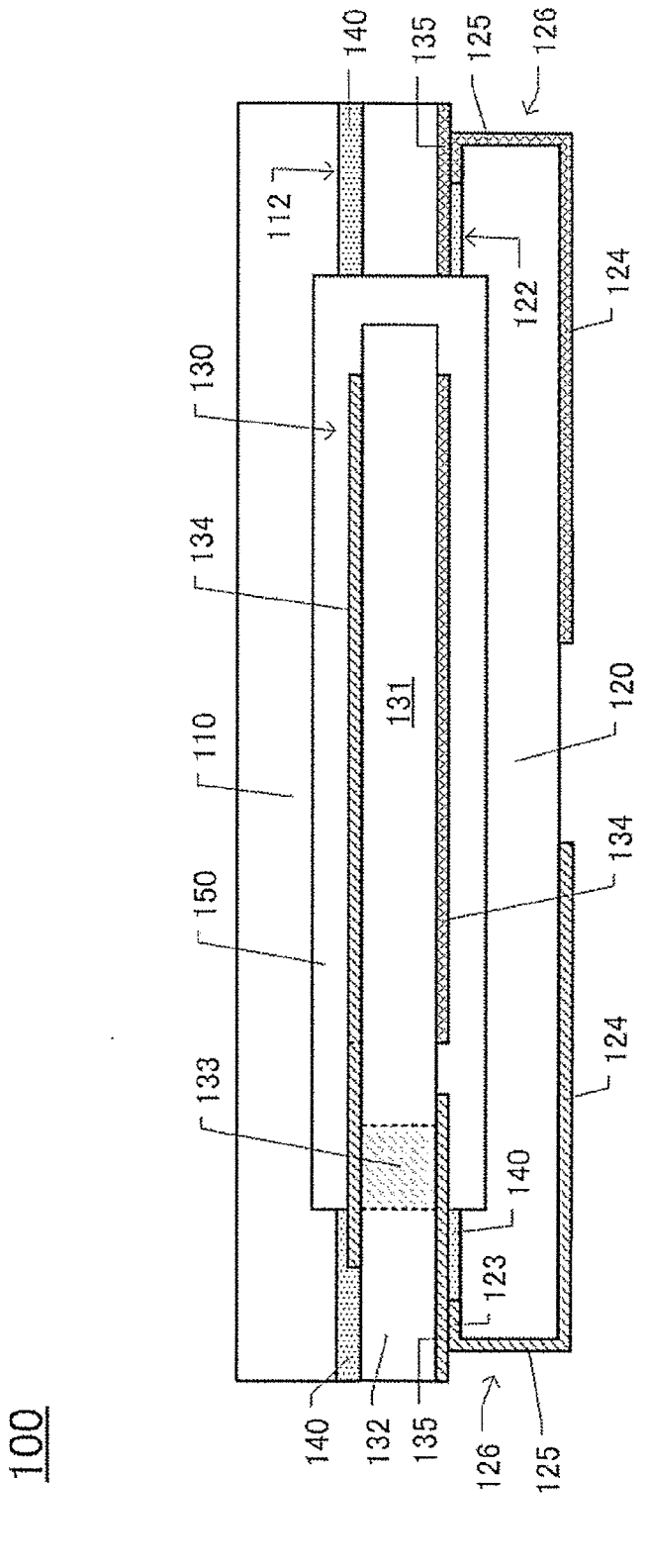

100
140
135
125
126
112
122
124
130
134
131
110
120
150
134
133
124
140
123
140
132
135
126
125
X
Y'
Z'

FIG.2

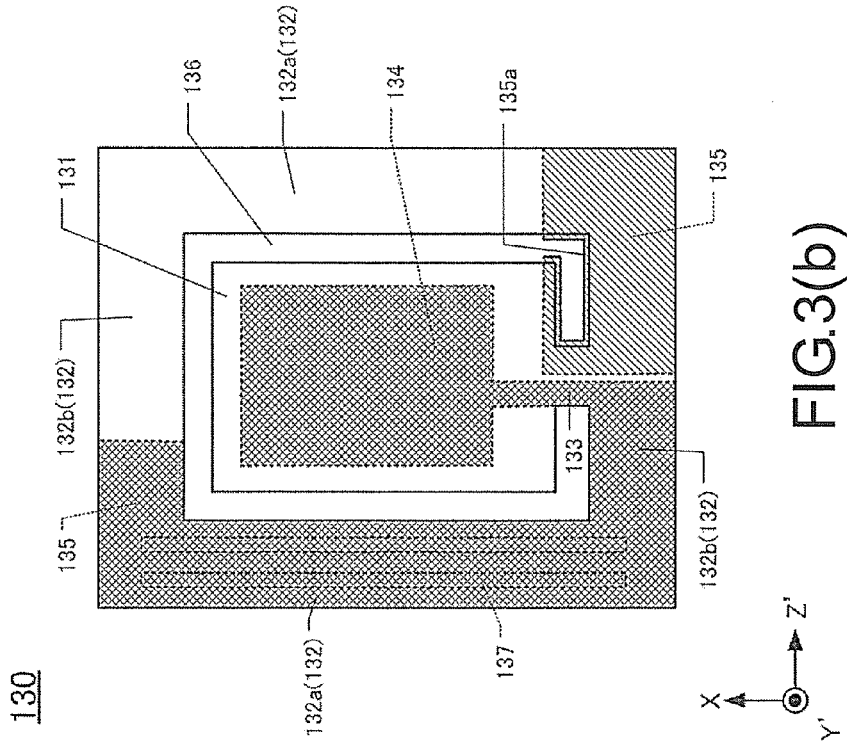

130
136
132a(132)
134
135a
135
131
132b(132)
133
135
132b(132)
132a(132)
137
Z'
X
Y'

FIG.3(b)

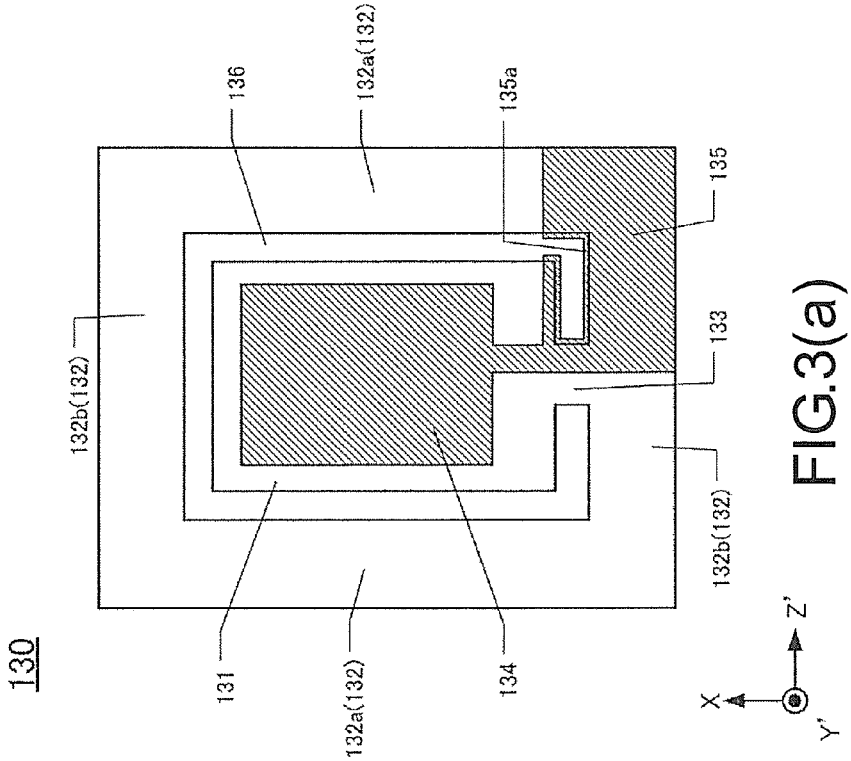

130
136
132a(132)
135a
135
132b(132)
133
132b(132)
131
132a(132)
134
Z'
X
Y'

FIG.3(a)

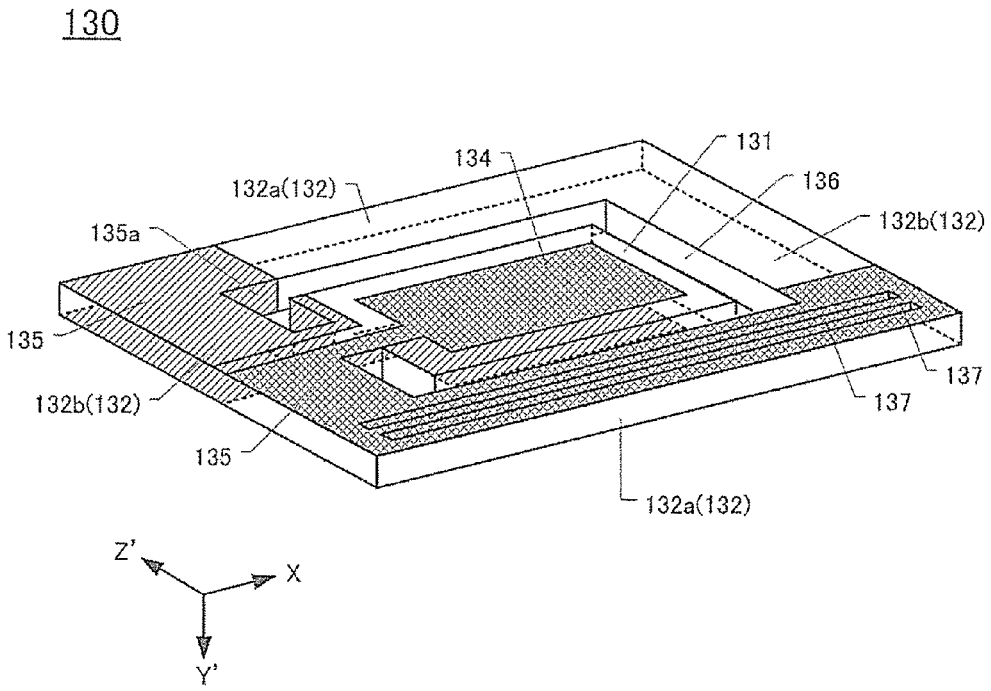

130
134
131
132a(132)
136
135a
132b(132)
135
137
132b(132)
137
135
132a(132)
Z'
X
Y'

FIG.4(a)

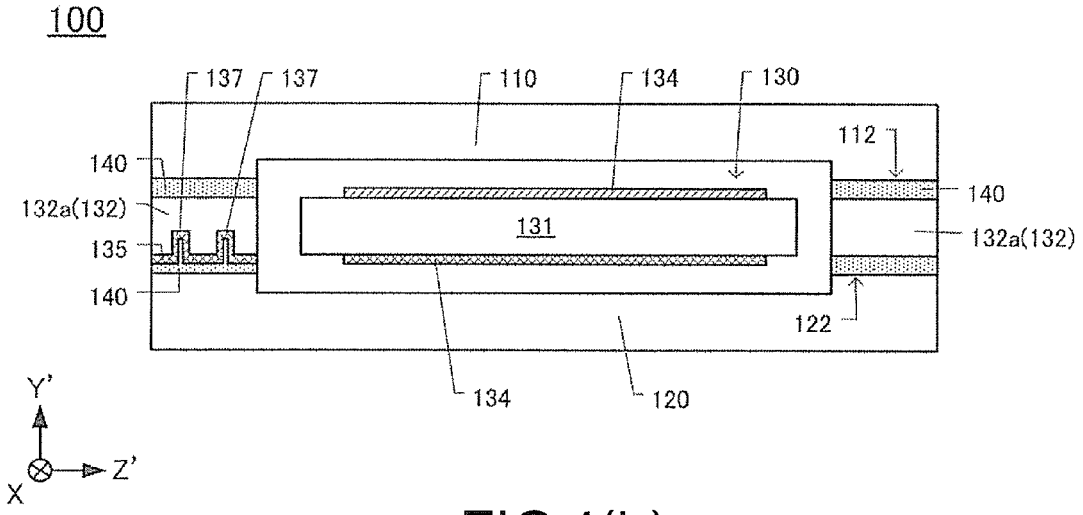

100
137
137
110
134
130
112
140
140
132a(132)
131
135
132a(132)
140
122
134
120
Y'
Z'
X

FIG.4(b)

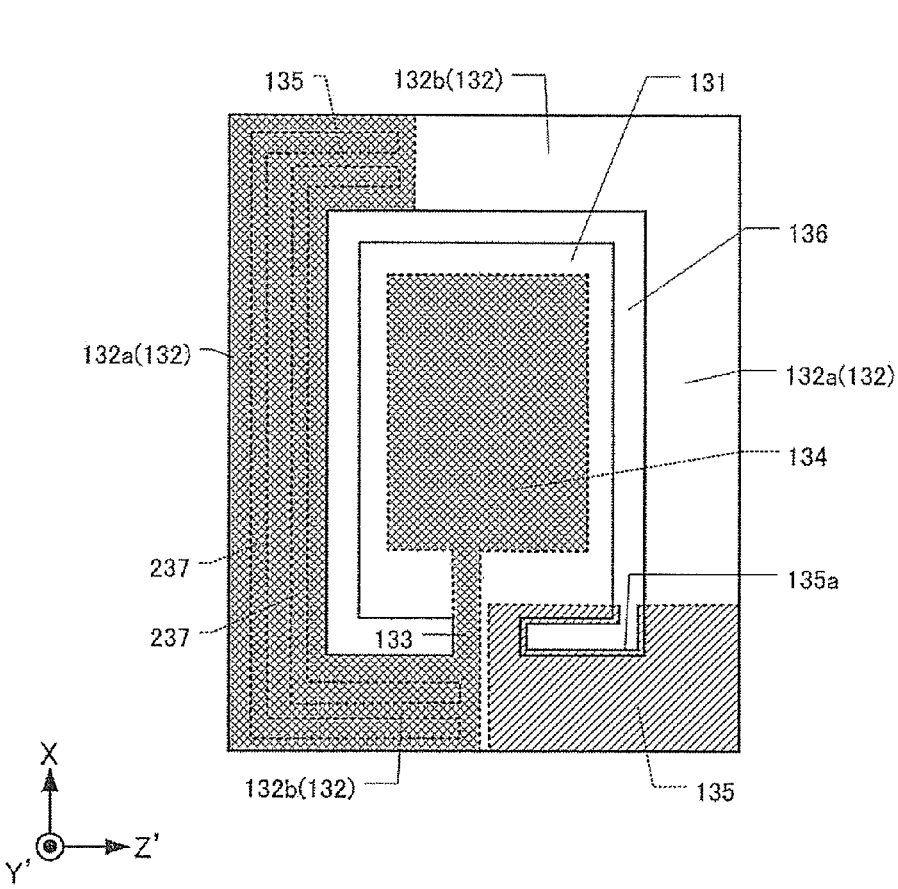

230
135
132b(132)
131
136
132a(132)
132a(132)
134
237
135a
237
133
132b(132)
135
X
Z'
Y'

FIG.5(a)

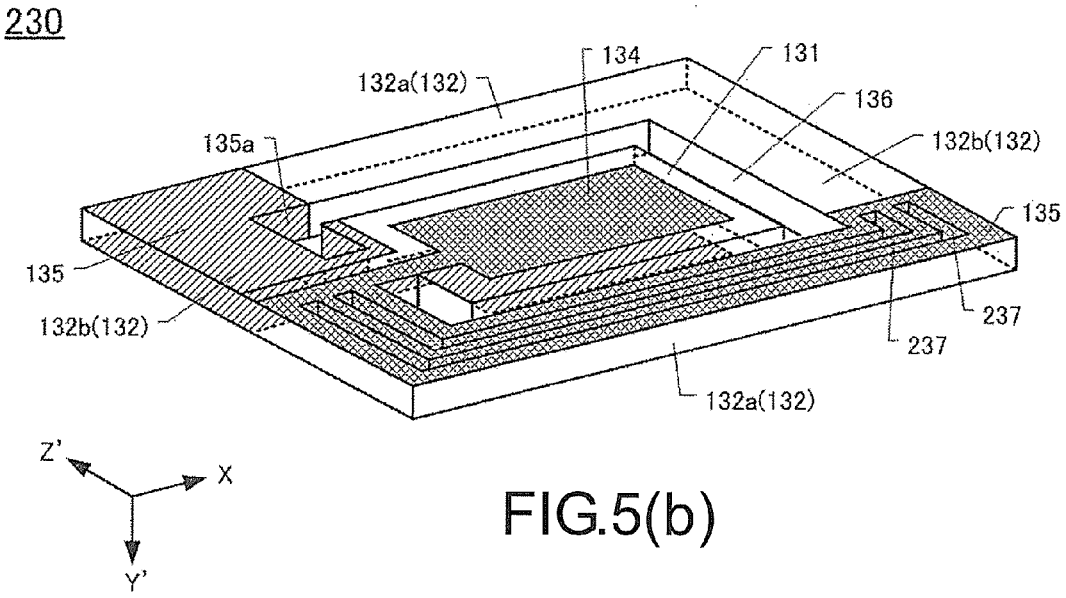

230
134
131
132a(132)
136
135a
132b(132)
135
135
237
132b(132)
237
132a(132)
Z'
X
Y'

FIG.5(b)

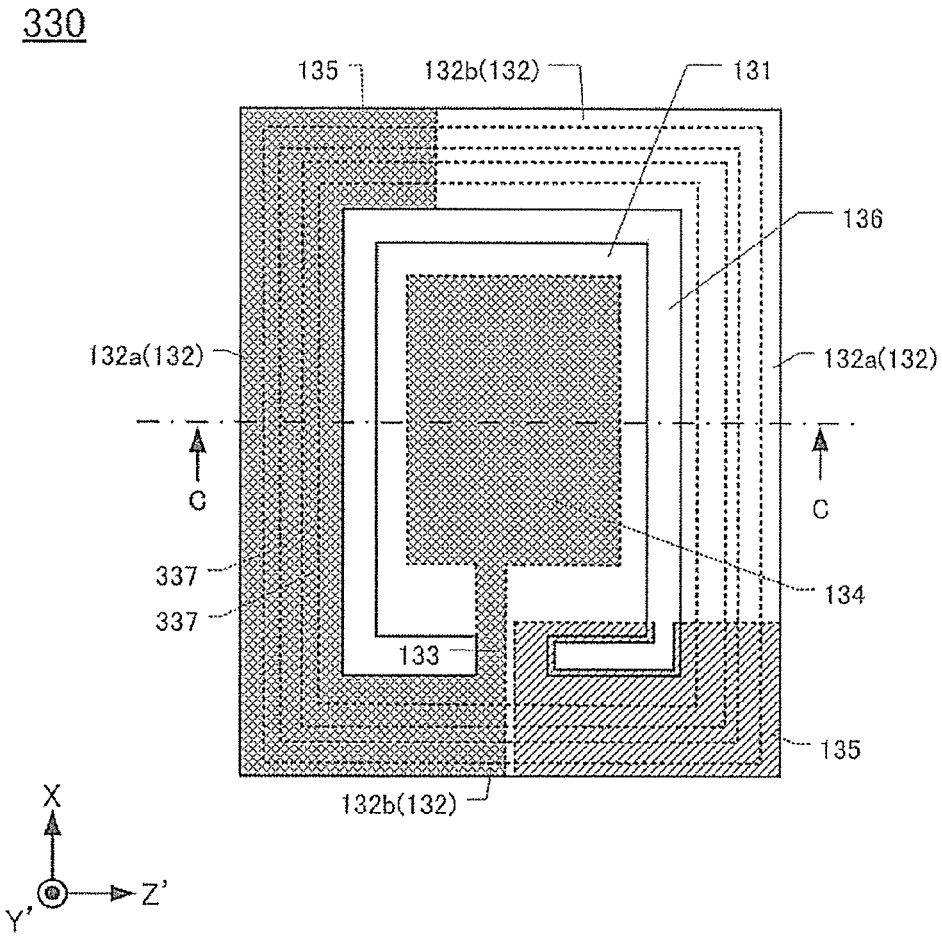

330
135
132b(132)
131
136
132a(132)
132a(132)
C
C
337
337
134
133
135
132b(132)
X
Y'
Z'

FIG.6(a)

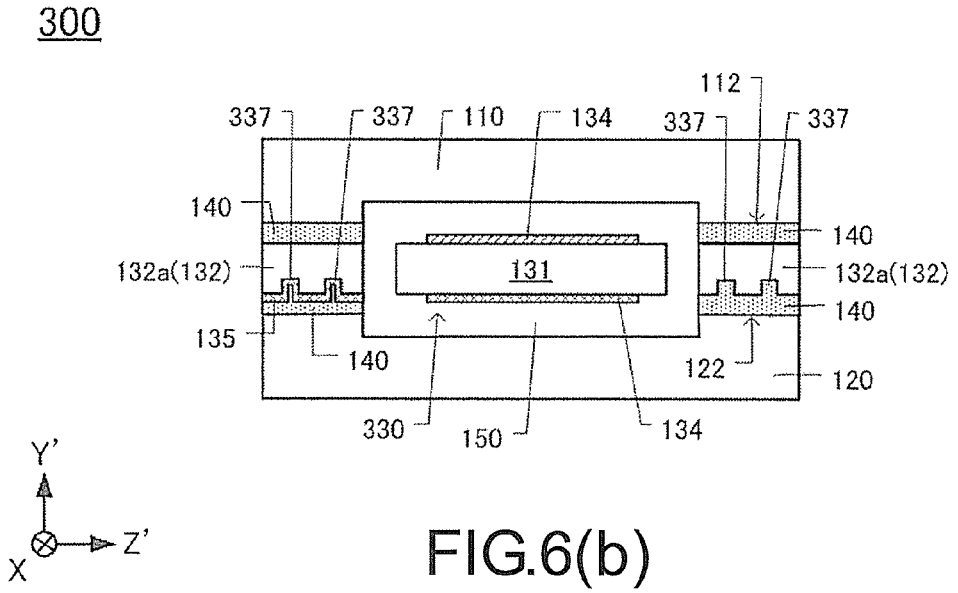

300
112
337
337
110
134
337
337
140
140
132a(132)
131
132a(132)
140
135
140
122
120
330
150
134
Y'
Z'
X

FIG.6(b)

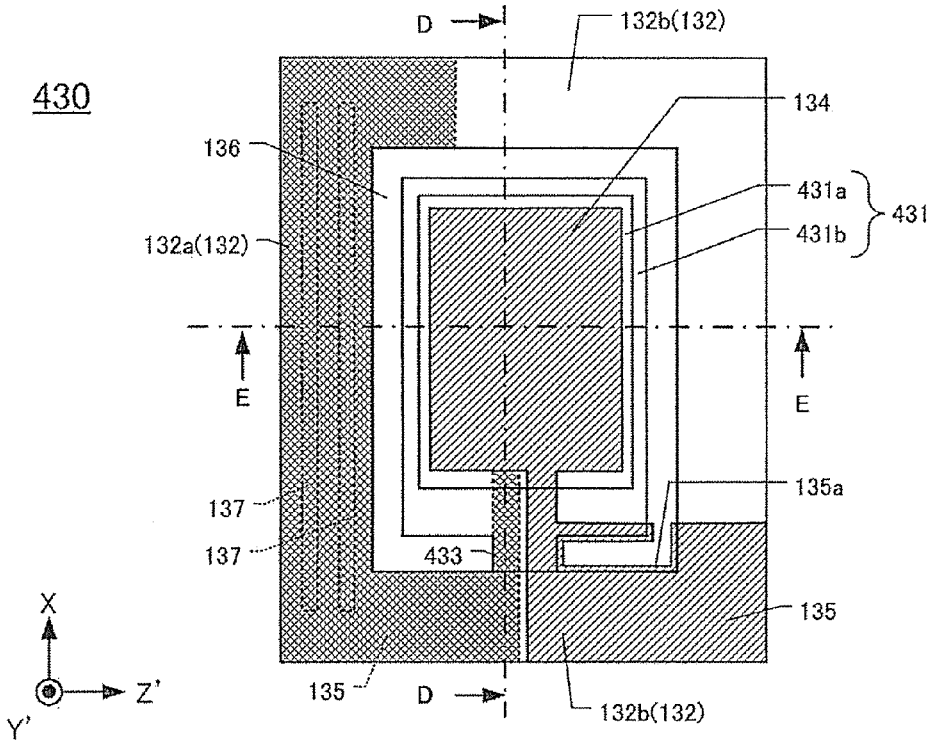


FIG.7(a)

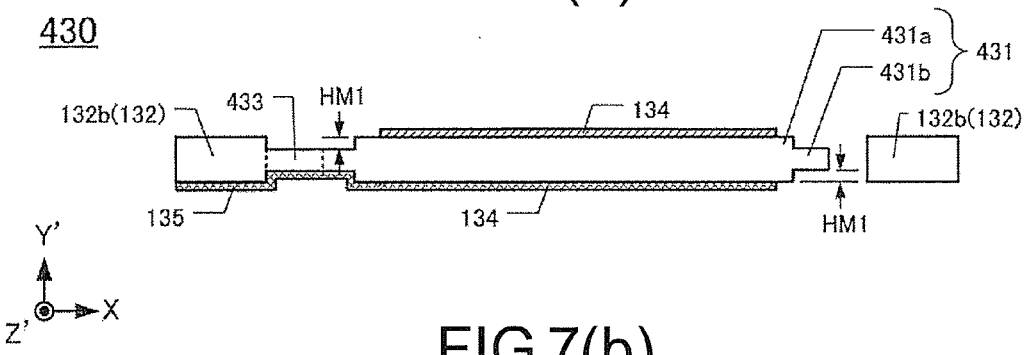


FIG.7(b)

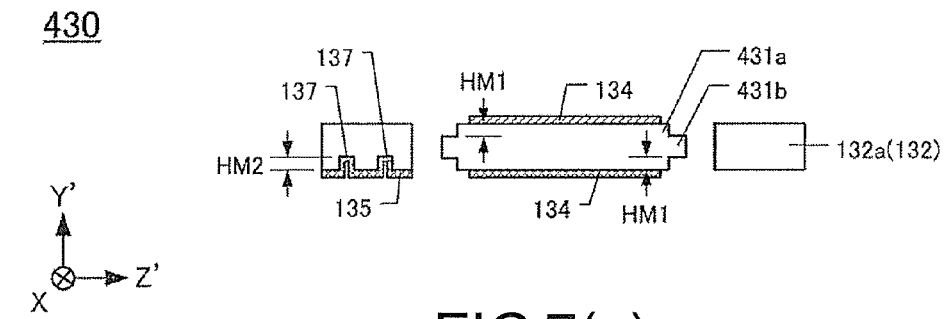


FIG.7(c)

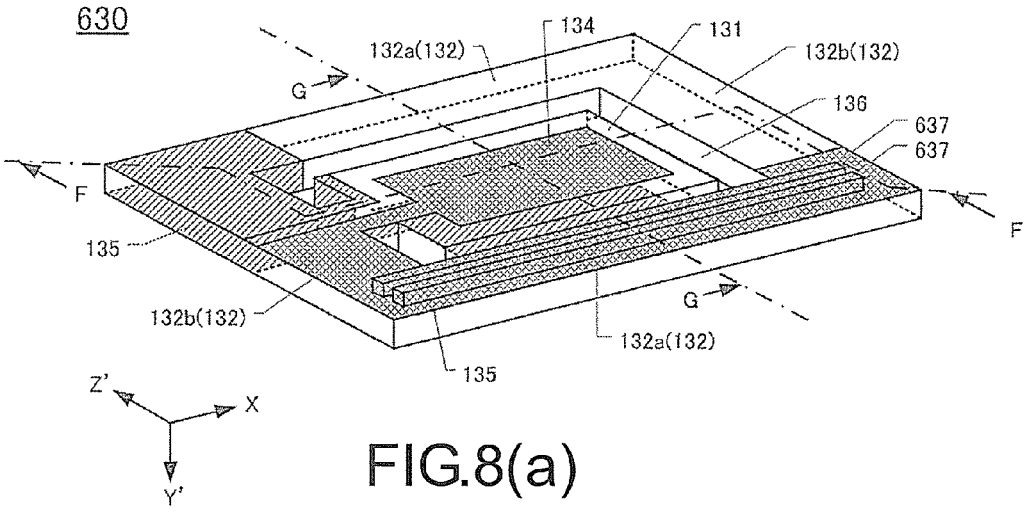


FIG.8(a)

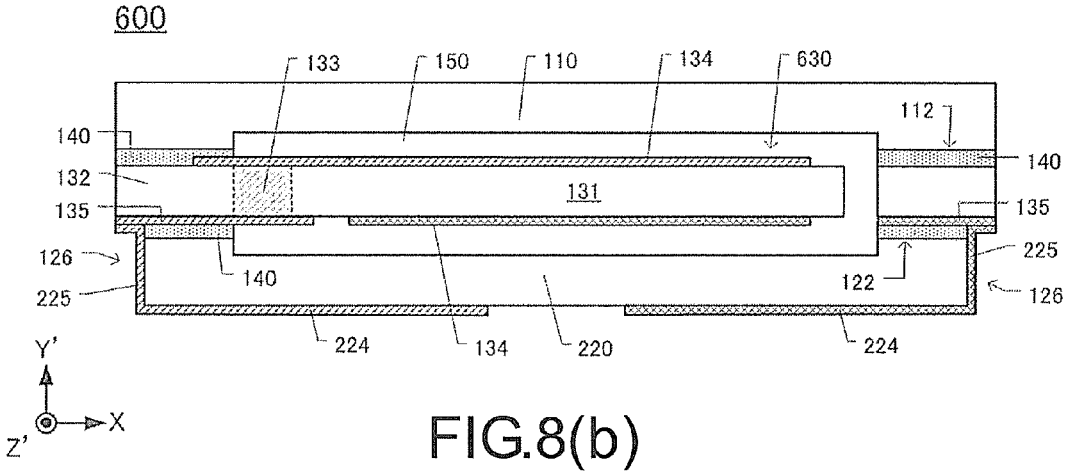


FIG.8(b)

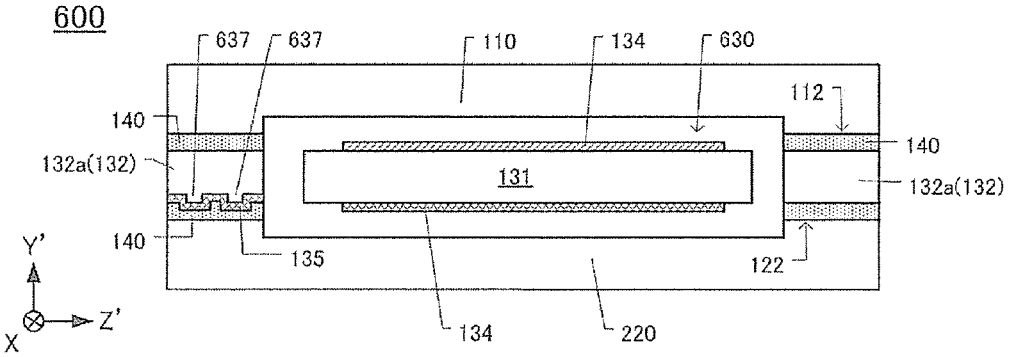


FIG.8(c)

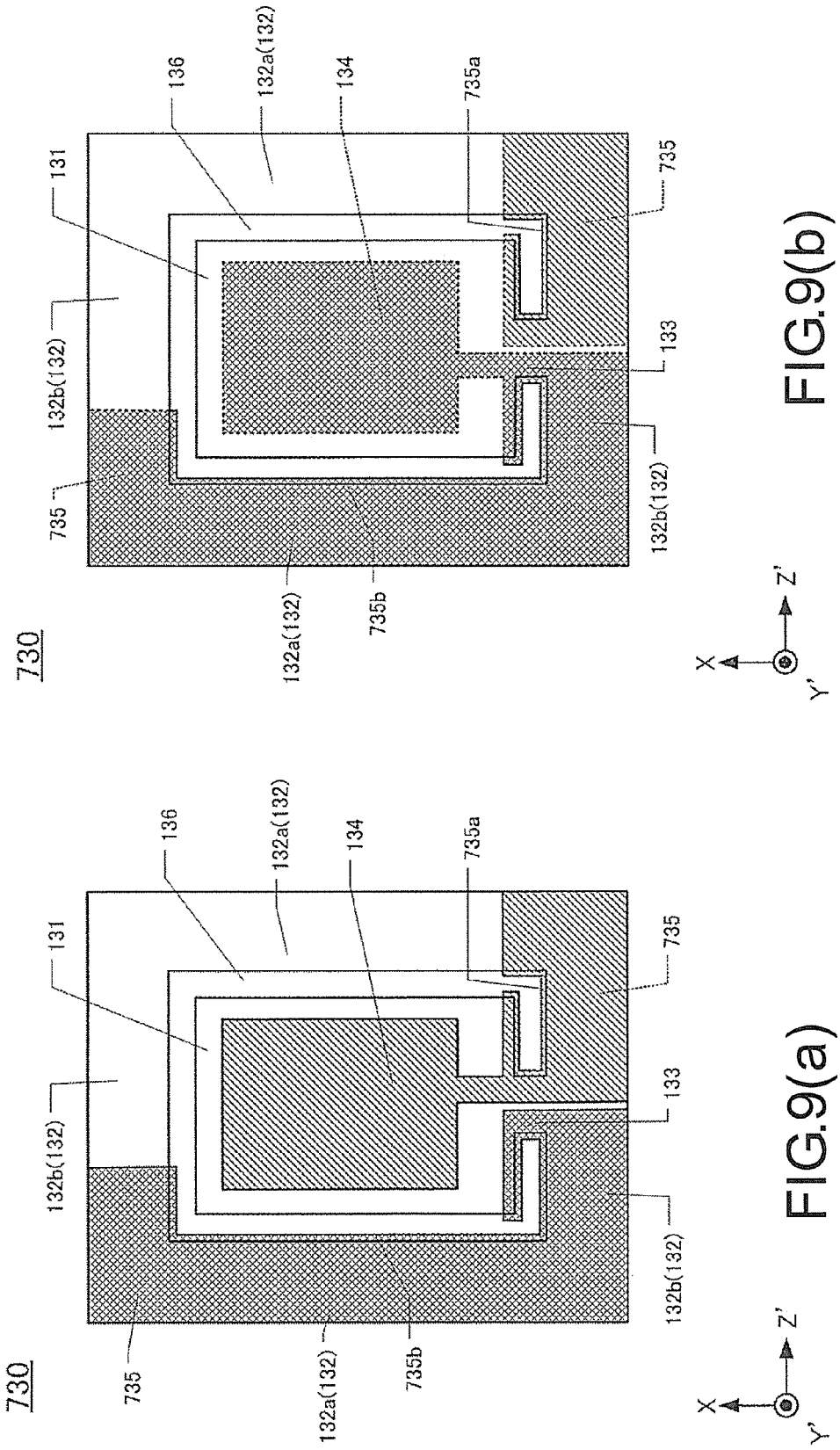

730
136
132a(132)
134
735a
131
735
132b(132)
133
735
132b(132)
132a(132)
735b
Z'
X
Y'
730
136
132a(132)
134
735a
131
735
132b(132)
133
735
132a(132)
735b
132b(132)
Z'
X
Y'

FIG.9(b)

FIG.9(a)

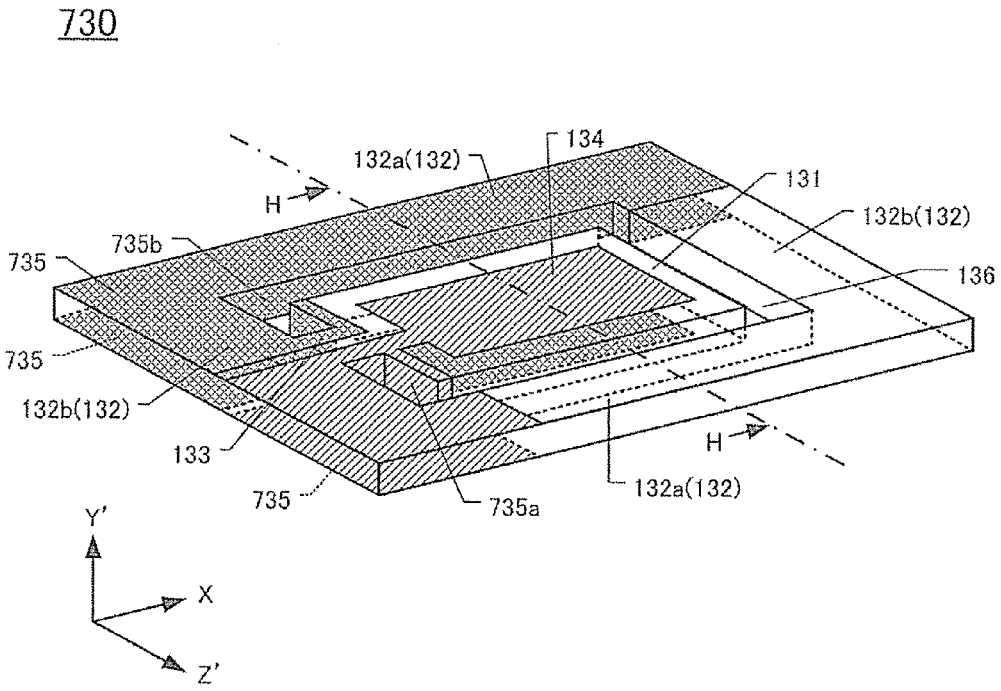


FIG.10(a)

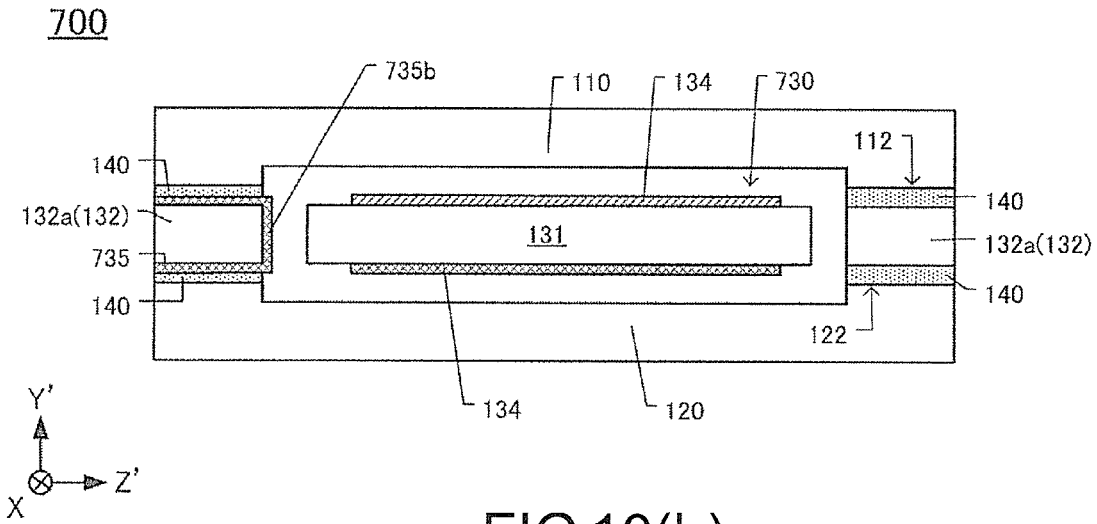


FIG.10(b)

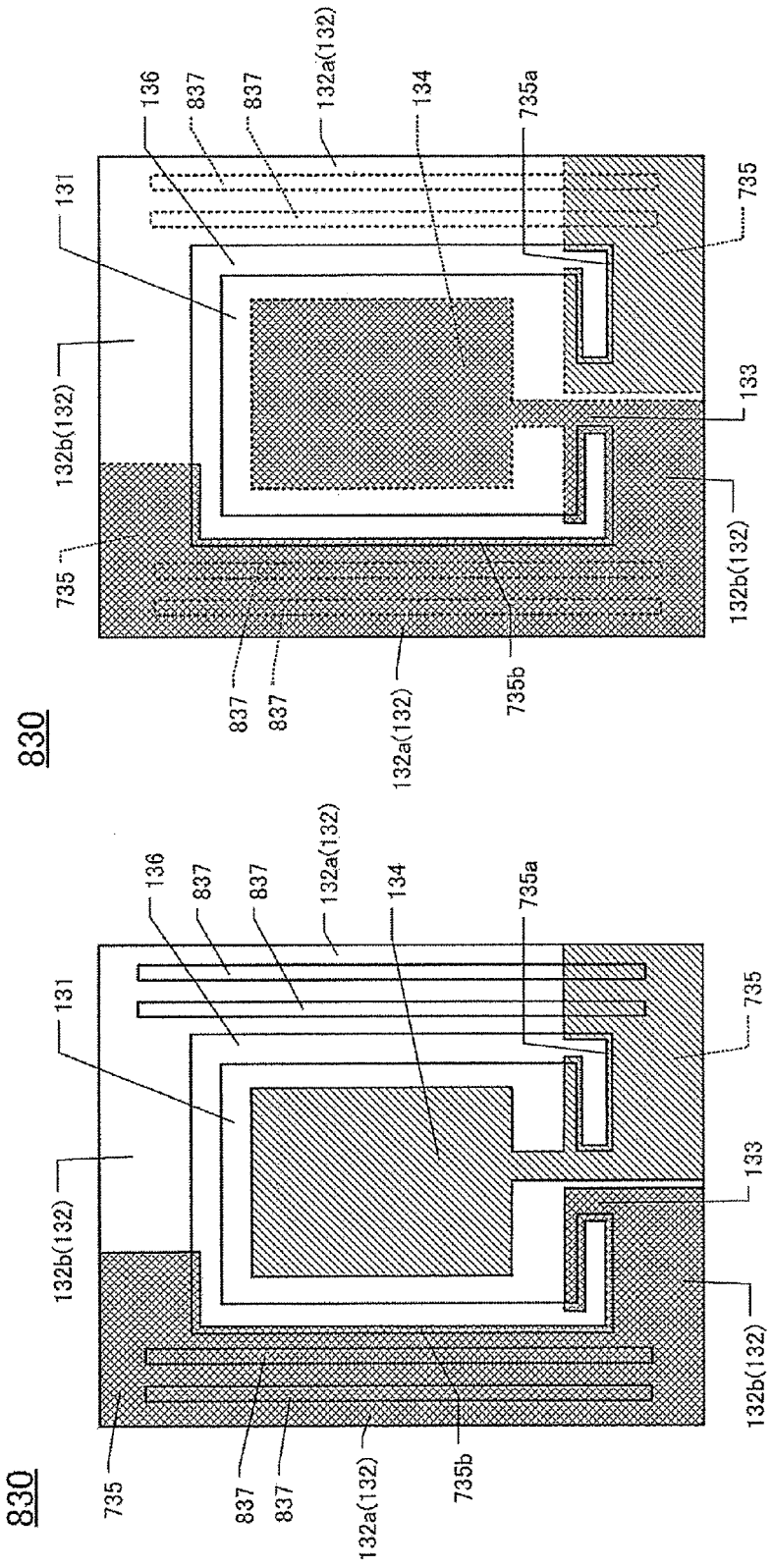


FIG.11(b)

FIG.11(a)

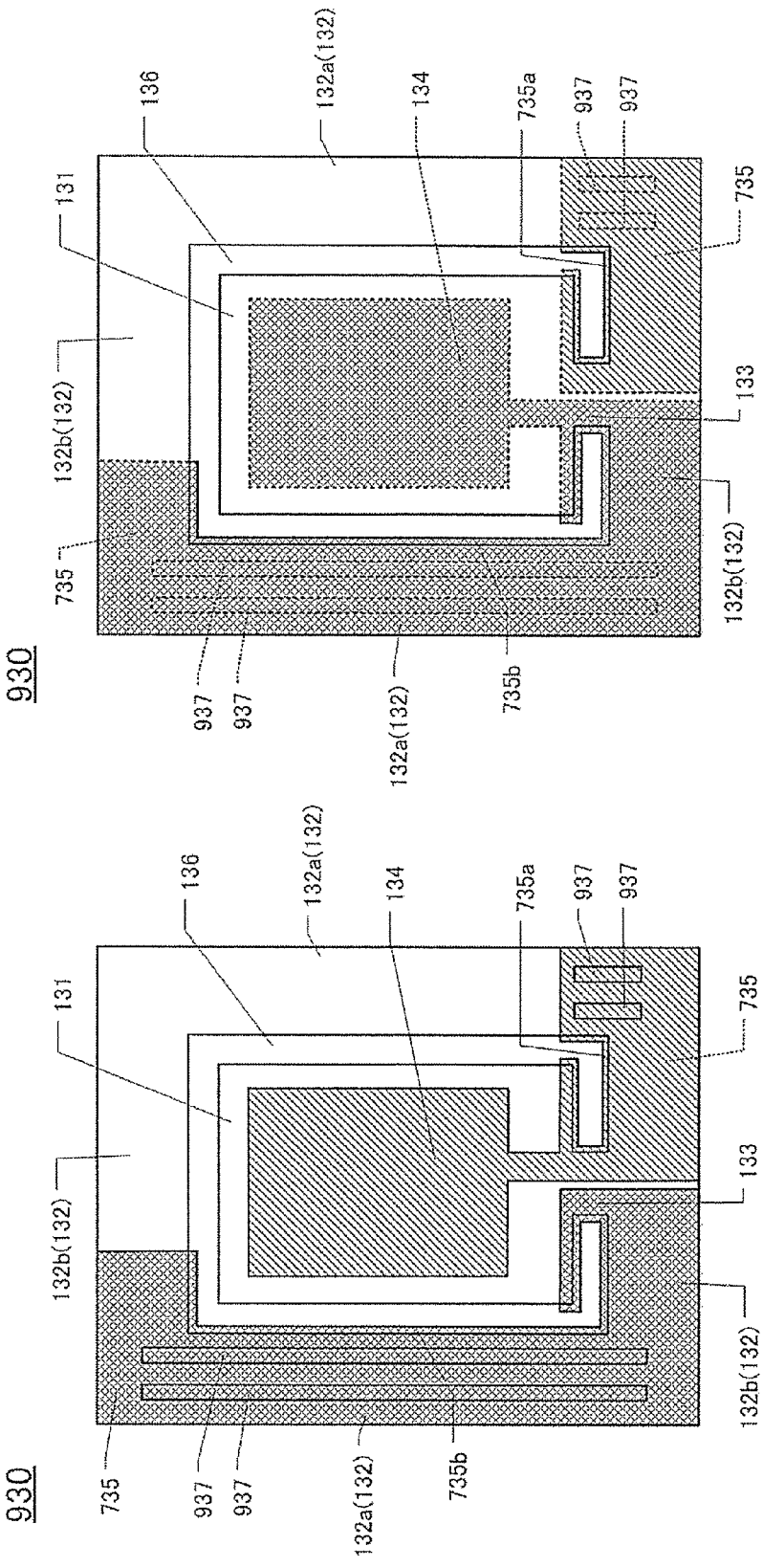


FIG.12(a)

FIG.12(b)

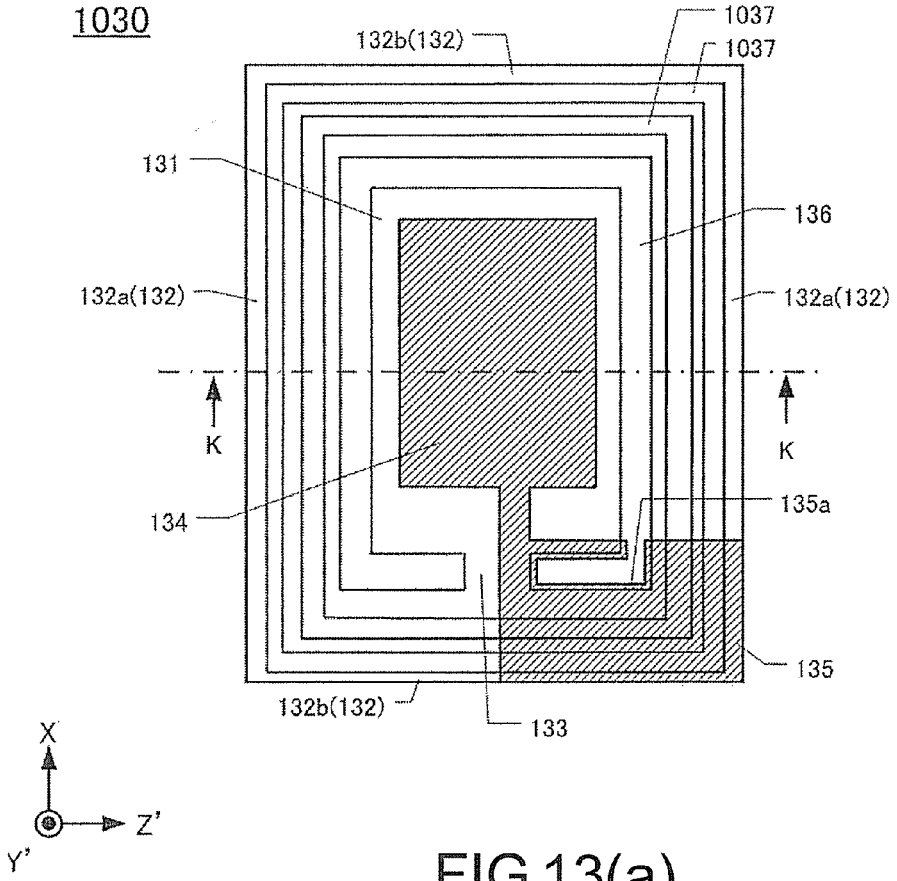


FIG.13(a)

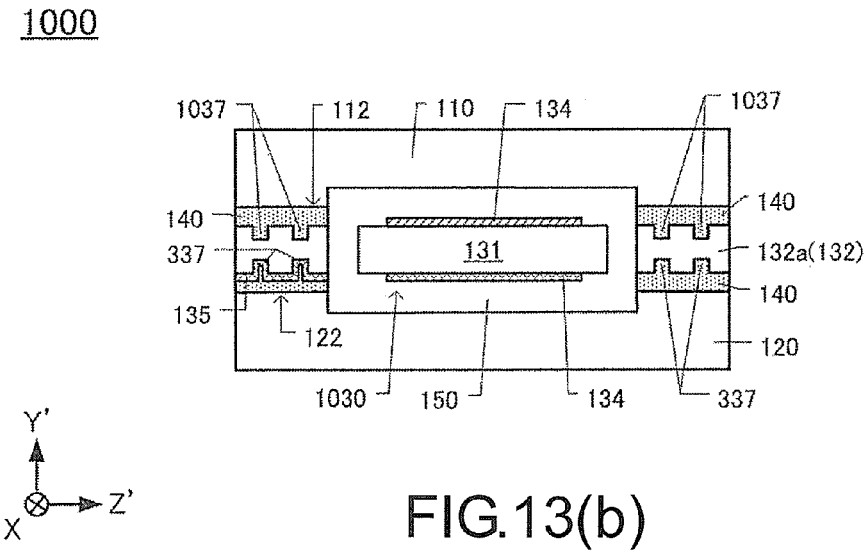


FIG.13(b)

PIEZOELECTRIC VIBRATING PIECE AND PIEZOELECTRIC DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Japan application serial no. 2012-132641, filed on Jun. 12, 2012. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

TECHNICAL FIELD

[0002] This disclosure relates to a piezoelectric vibrating piece where a framing portion is formed and a piezoelectric device.

DESCRIPTION OF THE RELATED ART

[0003] A piezoelectric vibrating piece that includes a vibrator vibrating at a predetermined vibration frequency, a framing portion surrounding the vibrator, and a connecting portion connecting the vibrator and the framing portion is known. In this piezoelectric vibrating piece, a base plate and a lid plate are bonded on one principal surface and the other principal surface of the framing portion via a bonding material, respectively, to form a piezoelectric device. A pair of excitation electrodes is formed on both principal surfaces of the vibrator of the piezoelectric vibrating piece. Extraction electrodes are extracted from each excitation electrode to the framing portion. In the piezoelectric vibrating piece, increasing an electrical resistance of this extraction electrode increases the crystal impedance (CI), which is a problem. Accordingly, it is preferred that the extraction electrode be formed with a small electrical resistance due to an increased extraction electrode area or similar reason. For example, Japanese Unexamined Patent Application Publication No. 2006-311015 (hereinafter referred to as Patent Literature 1) discloses a piezoelectric vibrating piece where an area of the extraction electrode extracted to a stepped part between a vibrator and a peripheral portion formed at a peripheral area of the vibrator is formed large.

[0004] However, in Patent Literature 1, only a short and partial part of the entire path of the extraction electrode is formed large. A reduction in an electrical resistance of the entire extraction electrode is not described.

[0005] A need thus exists for a piezoelectric vibrating piece and a piezoelectric device which are not susceptible to the drawback mentioned above.

SUMMARY

[0006] A piezoelectric vibrating piece according to a first aspect includes a vibrator, a framing portion, and a connecting portion. The vibrator has a rectangular shape and vibrates at a predetermined vibration frequency. The vibrator includes excitation electrodes on both principal surfaces. The framing portion surrounds a peripheral area of the vibrator. The framing portion includes a first framing body and a second framing body. The first framing body extends in a long side direction. The second framing body extends in a short side direction. The connecting portion connects the vibrator and the framing portion. The first framing body includes a depressed portion or an extruding part on one principal surface. The depressed portion or the extruding part extends in a long side direction. The piezoelectric vibrating piece further includes an extraction electrode extending from the excitation electrode via the connecting portion. The extraction electrode extends from one end to another end of the one principal surface of the first framing body. The first framing body includes the depressed portion or the extruding part.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The foregoing and additional features and characteristics of this disclosure will become more apparent from the following detailed description considered with the reference to the accompanying drawings, wherein:

[0008] FIG. **1** is an exploded perspective view of a piezoelectric device **100**;

[0009] FIG. **2** is a cross-sectional view taken along the line A-A of FIG. **1**;

[0010] FIG. **3**(*a*) is a plan view of a piezoelectric vibrating piece **130**;

[0011] FIG. **3**(*b*) is a plan view of the piezoelectric vibrating piece **130** where the surface at the −Y'-axis side of the piezoelectric vibrating piece **130** is transparently viewed from the +Y'-axis side;

[0012] FIG. **4**(*a*) is a perspective view of the piezoelectric vibrating piece **130** on the surface at the −Y'-axis side;

[0013] FIG. **4**(*b*) is a cross-sectional view taken along the line B-B of FIG. **1**;

[0014] FIG. **5**(*a*) is a plan view of a piezoelectric vibrating piece **230** on a surface at the −Y'-axis side viewed from the +Y'-axis side;

[0015] FIG. **5**(*b*) is a perspective view of the piezoelectric vibrating piece **230** on a surface at the −Y'-axis side;

[0016] FIG. **6**(*a*) is a plan view of a piezoelectric vibrating piece **330** on a surface at the −Y'-axis side transparently viewed from the +Y'-axis side;

[0017] FIG. **6**(*b*) is a cross-sectional view of a piezoelectric device **300**;

[0018] FIG. **7**(*a*) is a plan view of a piezoelectric vibrating piece **430**;

[0019] FIG. **7**(*b*) is a cross-sectional view taken along the line D-D of FIG. **7**(*a*);

[0020] FIG. **7**(*c*) is a cross-sectional view taken along the line E-E of FIG. **7**(*a*);

[0021] FIG. **8**(*a*) is a perspective view of a piezoelectric vibrating piece **630** on a surface at the −Y'-axis side;

[0022] FIG. **8**(*b*) is a cross-sectional view of a piezoelectric device **600**;

[0023] FIG. **8**(*c*) is a cross-sectional view of the piezoelectric device **600**;

[0024] FIG. **9**(*a*) is a plan view of a piezoelectric vibrating piece **730** at the +Y'-axis side;

[0025] FIG. **9**(*b*) is a plan view of the piezoelectric vibrating piece **730** on the surface at the −Y'-axis side viewed from the +Y'-axis side;

[0026] FIG. **10**(*a*) is a perspective view of the piezoelectric vibrating piece **730**;

[0027] FIG. **10**(*b*) is a cross-sectional view of a piezoelectric device **700**;

[0028] FIG. **11**(*a*) is a plan view of a piezoelectric vibrating piece **830** on the surface at the +Y'-axis side;

[0029] FIG. **11**(*b*) is a plan view of the piezoelectric vibrating piece **830** on a surface at the −Y'-axis side;

[0030] FIG. **12**(*a*) is a plan view of a piezoelectric vibrating piece **930** on a surface at the +Y'-axis side;

[0031] FIG. **12**(*b*) is a plan view of the piezoelectric vibrating piece **930** on a surface at the −Y'-axis side;

[0032] FIG. **13**(*a*) is a plan view of a piezoelectric vibrating piece **1030**; and

[0033] FIG. **13**(*b*) is a cross-sectional view of a piezoelectric device **1000**.

DETAILED DESCRIPTION

[0034] The preferred embodiments of this disclosure will be described with reference to the attached drawings. It will be understood that the scope of the disclosure is not limited to the described embodiments, unless otherwise stated.

Constitution of a Piezoelectric Device **100** According to a First Embodiment

[0035] FIG. **1** is an exploded perspective view of the piezoelectric device **100**. The piezoelectric device **100** includes a lid plate **110**, a base plate **120**, and a piezoelectric vibrating piece **130**. An AT-cut quartz-crystal vibrating piece, for example, is employed for the piezoelectric vibrating piece **130**. The AT-cut quartz-crystal vibrating piece has a principal surface (in the Y-Z plane) that is tilted by 35°15' about the Y-axis of crystallographic axes (XYZ) in the direction from the Z-axis to the Y-axis around the X-axis. In the following description, the new axes tilted with reference to the axis directions of the AT-cut quartz-crystal vibrating piece are denoted as the Y'-axis and the Z'-axis. This disclosure defines the long side direction of the piezoelectric device **100** as the X-axis direction, the height direction of the piezoelectric device **100** as the Y'-axis direction, and the direction perpendicular to the X and Y'-axis directions as the Z'-axis direction.

[0036] The piezoelectric vibrating piece **130** includes a vibrator **131**, a framing portion **132**, and one connecting portions **133**. The vibrator **131** vibrates at a predetermined vibration frequency and has a rectangular shape. The framing portion **132** surrounds the vibrator **131**. The connecting portion **133** connects the vibrator **131** and the framing portion **132**. The framing portion **132** includes a pair of first framing bodies **132***a* and a pair of second framing bodies **132***b*. The pair of first framing bodies **132***a* are disposed at the +Z'-axis side and the −Z'-axis side of the vibrator **131** and extend in the X-axis direction, which is the long side direction. The pair of second framing bodies **132***b* are disposed at the +X-axis side and the −X-axis side of the vibrator **131** and extend in the Z'-axis direction, which is the short side direction). The connecting portion **133** connects the center of the side at the −X-axis side of the vibrator **131** and the center at the −X-axis side of the second framing body **132***b*. In a region other than the connecting portion **133** between the vibrator **131** and the framing portion **132**, a through groove **136** that passes through the piezoelectric vibrating piece **130** in the Y'-axis direction is formed. Excitation electrodes **134** are formed on surfaces at the +Y'-axis side and at the −Y'-axis side of the vibrator **131**. An extraction electrode **135** is extracted from each excitation electrode **134** to the framing portion **132** through the connecting portion **133**. Additionally, a depressed portion **137** is formed at the first framing body **132***a* at the −Z'-axis side on the surface at the −Y'-axis side. The depressed portion **137** is depressed at the +Y'-axis side.

[0037] The base plate **120** includes a depressed portion **121**, a bonding surface **122**, and connecting electrodes **123** on the surface at the +Y'-axis side. The depressed portion **121** is depressed at −Y'-axis side. The bonding surface **122** surrounds the depressed portion **121**. The connecting electrodes **123** are disposed at corners at the +X-axis side and the −Z'-axis side and at the −X-axis side and the +Z'-axis side of the bonding surface **122**. The bonding surface **122** is to be bonded to the framing portion **132** on the surface at the −Y'-axis side of the piezoelectric vibrating piece **130** via a bonding material **140** (see FIG. **2**). Additionally, a pair of mounting terminals **124** is formed on the surface at the −Y'-axis side of the base plate **120**. Furthermore, castellations **126** are formed at four corners of side surfaces of the base plate **120**. Castellation electrodes **125** are formed on side surfaces at the +X-axis side and the −Z'-axis side and at the −X-axis side and the +Z'-axis side of the castellation **126**. The castellation electrode **125** electrically connects the connecting electrode **123** and the mounting terminal **124**. The connecting electrode **123** formed on the corner at the −X-axis side and at the +Z'-axis side electrically connects to the extraction electrode **135** formed on the corner at the −X-axis side and the +Z'-axis side on the surface at the −Y-axis side of the piezoelectric vibrating piece **130**. The connecting electrode **123** formed on the corner at the +X-axis side and at the −Z'-axis side electrically connects to the extraction electrode **135** formed on the corner at the +X-axis side and the −Z'-axis side on the surface at the −Y-axis side of piezoelectric vibrating piece **130**.

[0038] The lid plate **110** includes a depressed portion **111** and a bonding surface **112** on the surface at the −Y'-axis side. The bonding surface **112** surrounds the depressed portion **111**. The bonding surface **112** is to be bonded on the surface at the +Y'-axis side of the framing portion **132** of the piezoelectric vibrating piece **130** via the bonding material **140** (see FIG. **2**).

[0039] FIG. **2** is a cross-sectional view taken along the line A-A of FIG. **1**. The piezoelectric device **100** includes the lid plate **110** at the +Y'-axis side and the base plate **120** at the −Y'-axis side of the piezoelectric vibrating piece **130**. Additionally, the piezoelectric device **100** includes a cavity **150** formed by the depressed portion **111** of the lid plate **110** and the depressed portion **121** of the base plate **120**. The vibrator **131** of the piezoelectric vibrating piece **130** is disposed in the cavity **150**. The cavity **150** is sealed by forming the bonding materials **140** between the bonding surface **112** of the lid plate **110** and the surface at the +Y'-axis side of the framing portion **132**, and between the bonding surface **122** of the base plate **120** and the surface at the −Y'-axis side of the framing portion **132**. When the extraction electrode **135** formed at the framing portion **132** electrically connects to the connecting electrode **123** formed at the base plate **120**, the excitation electrode **134** electrically connects to the mounting terminal **124**.

[0040] FIG. **3**(*a*) is a plan view of the piezoelectric vibrating piece **130**. The piezoelectric vibrating piece **130** is formed by connecting the center of the side at the −X-axis side of the rectangular vibrator **131** and the center of the second framing body **132***b* at the −X-axis side by the connecting portion **133**. The excitation electrode **134** is formed at the center of the vibrator **131**. The extraction electrode **135** is extracted from the excitation electrode **134** to the −X-axis side and the +Z'-axis side of the framing portion **132**. The extraction electrode **135** is extracted to the surface at the −Y'-axis side via a side surface electrode **135***a*. The side surface electrode **135***a* is a part of the extraction electrode **135** and is formed at the side surface at the end of the −X-axis side and the +Z'-axis side of the through groove **136**.

[0041] FIG. **3**(*b*) is a plan view of the piezoelectric vibrating piece **130** where the surface at the −Y'-axis side of the piezoelectric vibrating piece **130** is transparently viewed from the +Y'-axis side. The piezoelectric vibrating piece **130**

includes the excitation electrode **134** at the center of the vibrator **131** on the surface at the −Y'-axis side. From this excitation electrode **134**, the extraction electrode **135** is extracted to the end at the +X-axis side and the −Z'-axis side of the framing portion **132** via the connecting portion **133**, the second framing body **132***b* at the −X-axis side, and the first framing body **132***a* at the −Z'-axis side. Additionally, the extraction electrode **135** extracted from the surface at the +Y'-axis side to the surface at the −Y'-axis side via the side surface electrode **135***a* is extracted to the end at the −X-axis side and the +Z'-axis side of the framing portion **132** on the surface at the −Y'-axis side. Two depressed portions **137** extend in the X-axis direction at the −Z'-axis side of the first framing body **132***a* on the surface at the −Y'-axis side.

[0042] FIG. **4**(*a*) is a perspective view of the piezoelectric vibrating piece **130** on the surface at the −Y'-axis side. The two depressed portions **137** are formed at the −Z'-axis side of the first framing body **132***a* on the surface at the −Y'-axis side. Each depressed portion **137** is formed from near the end portion at the −X-axis side to near the end portion at the +X-axis side at the −Z'-axis side of the first framing body **132***a*. The extraction electrode **135** is formed at the entire depressed portions **137**. Forming the depressed portion **137** expands the surface area of the extraction electrode **135** formed at the −Z'-axis side of the first framing body **132***a* on the surface at the −Y'-axis side compared with the case where the depressed portion **137** is not formed.

[0043] FIG. **4**(*b*) is a cross-sectional view taken along the line B-B of FIG. **1**. The depressed portion **137** is formed at the first framing body **132***a* at the −Z'-axis side of the piezoelectric vibrating piece **130**. Forming the extraction electrode **135** at the depressed portion **137** expands the width of the extraction electrode **135** relative to a current flowing in the X-axis direction. An electrical resistance is reduced at the extraction electrode **135** formed at the −Z'-axis side of the first framing body **132***a* relative to a current flowing in the X-axis direction. Accordingly, a crystal impedance (CI) of the piezoelectric vibrating piece **130** can be decreased.

Second Embodiment

[0044] With the piezoelectric vibrating piece **130**, various modifications are applicable to shapes of a depressed portion and the piezoelectric vibrating piece. A description will be given of the modifications of the piezoelectric vibrating piece **130**, which includes a piezoelectric vibrating piece **230**, a piezoelectric vibrating piece **330**, and a piezoelectric vibrating piece **430**. Like reference numerals designate corresponding or identical elements throughout the first embodiment and the second embodiment, and therefore such elements will not be further elaborated here.

Constitution of the Piezoelectric Vibrating Piece **230**

[0045] FIG. **5**(*a*) is a plan view of the piezoelectric vibrating piece **230** on the surface at the −Y'-axis side transparently viewed from the +Y'-axis side. The piezoelectric vibrating piece **230** includes the vibrator **131**, the framing portion **132**, and the connecting portion **133**. The piezoelectric vibrating piece **230** further includes the excitation electrode **134** and the extraction electrode **135**. Two depressed portions **237** are formed at the −X-axis side and the −Z'-axis side of the second framing body **132***b*, at the −Z'-axis side of the second framing body **132***b*, and near the end portion at the −Z'-axis side and the +X-axis side of the framing portion **132** on the framing portion **132** on the surface at the −Y'-axis side where the extraction electrode **135** is formed. The piezoelectric vibrating piece **230** has the surface at the +Y'-axis side same as that in FIG. **3**(*a*).

[0046] FIG. **5**(*b*) is a perspective view of the piezoelectric vibrating piece **230** on the surface at the −Y'-axis side. The extraction electrode **135** is formed at the entire depressed portions **237** formed at the piezoelectric vibrating piece **230**. Forming the depressed portion **237** expands the surface area of the extraction electrode **135** formed from the second framing body **132***b* at the −X-axis side to near the −Z'-axis side of the second framing body **132***b* at the +X-axis side via the first framing body **132***a* at the −Z'-axis side compared with the case where the depressed portion **237** is not formed. Since this widens the extraction electrode **135** relative to a current flowing in the X-axis direction, an electrical resistance is reduced. Accordingly, a crystal impedance (CI) of the piezoelectric vibrating piece **230** can be decreased.

Constitution of a Piezoelectric Vibrating Piece **330**

[0047] FIG. **6**(*a*) is a plan view of the piezoelectric vibrating piece **330** on the surface at the −Y'-axis side transparently viewed from the +Y'-axis side. The piezoelectric vibrating piece **330** includes the vibrator **131**, the framing portion **132**, and the connecting portion **133**. The framing portion **132** includes two depressed portions **337** on the surface at the −Y'-axis side. The depressed portions **337** are depressed from the framing portion **132** on the surface at the −Y'-axis side in the +Y'-axis direction and surround the peripheral area of the vibrator **131**. The surface at the +Y'-axis side of the piezoelectric vibrating piece **330** is the same as that in FIG. **3**(*a*).

[0048] FIG. **6**(*b*) is a cross-sectional view of a piezoelectric device **300**. FIG. **6**(*b*) is a cross-sectional view including a cross section taken along the line C-C of FIG. **6**(*a*). The piezoelectric device **300** includes a piezoelectric vibrating piece **330**, the base plate **120**, and the lid plate **110**. The base plate **120** is to be bonded on the −Y'-axis side of the piezoelectric vibrating piece **330**. The lid plate **110** is to be bonded on the surface at the +Y'-axis side of the piezoelectric vibrating piece **330**. The piezoelectric vibrating piece **330** includes the depressed portion **337** at the framing portion **132** on the surface at the −Y'-axis side. The surface at the −Y'-axis side of the framing portion **132** is bonded to the bonding surface **122** of the base plate **120** via the bonding material **140**. The depressed portion **337** is formed corresponding to the bonding surface **122** that surrounds the peripheral area of the cavity **150** formed in the piezoelectric device **300**. This allows uniformly bonding the framing portion **132** and the bonding surface **122** without forming unevenness in bonding strength. Accordingly, stress applied between the framing portion **132** and the bonding surface **122** does not concentrate at a specific portion but disperses. Consequently, the bonding strength between the framing portion **132** and the bonding surface **122** improves, and this also improves sealing strength of the cavity **150**.

Constitution of a Piezoelectric Vibrating Piece **430**

[0049] FIG. **7**(*a*) is a plan view of the piezoelectric vibrating piece **430**. FIG. **7**(*a*) illustrates an electrode and depressed portions formed on the surface at the −Y'-axis side by dotted lines. The piezoelectric vibrating piece **430** includes a vibrator **431**, the framing portion **132**, and a connecting portion **433**. The vibrator **431** is formed at the center of the vibrator

431. The vibrator **431** includes a mesa region **431***a* and a peripheral region **431***b*. The mesa region **431***a* includes the excitation electrode **134**. The peripheral region **431***b* is a region other than the mesa region **431***a* and surrounds the mesa region **431***a*. From the excitation electrodes **134** formed at the mesa regions **431***a*, the respective extraction electrodes **135** are extracted to the framing portion **132** through the peripheral region **431***b* and the connecting portion **433**.

[0050] FIG. **7**(*b*) is a cross-sectional view taken along the line D-D of FIG. **7**(*a*). The piezoelectric vibrating piece **430** includes steps between the mesa region **431***a* at the +Y'-axis side and the peripheral region **431***b*, and between the mesa region **431***a* at the −Y'-axis side and the peripheral region **431***b*. The mesa region **431***a* is formed thicker than the peripheral region **431***b* in the Y'-axis direction. A height HM**1** of the step at the surface at the +Y'-axis side of the vibrator **431** is equal to a height HM**1** of the step at the surface at the −Y'-axis side of the vibrator **431**. Additionally, the connecting portion **433** has the same thickness as a thickness of the peripheral region **431***b*.

[0051] FIG. **7**(*c*) is a cross-sectional view taken along the line E-E of FIG. **7**(*a*). The two depressed portions **137** are formed at the first framing body **132***a* at the −Z'-axis side on the surface at the −Y'-axis side. Assume that the depth of this depressed portion **137** is HM**2**. With the piezoelectric vibrating piece **430**, the height HM**1**, which is the height of the mesa region **431***a*, and the depth HM**2** are the same. The mesa region **431***a* and the depressed portion **137** can be formed by wet-etching the piezoelectric vibrating piece **430**. With the same dimension of the height HM**1** and the depth HM**2**, the mesa region **431***a* and the depressed portion **137** can be simultaneously formed by etching. This allows simplifying a formation process of the piezoelectric vibrating piece **430**.

Third Embodiment

[0052] An extruding part may be formed instead of a depressed portion formed at a framing portion of a piezoelectric vibrating piece. A description will be given of a piezoelectric vibrating piece **630** where the extruding part is formed. Like reference numerals designate corresponding or identical elements throughout the first embodiment and the third embodiment, and therefore such elements will not be further elaborated here.

Constitution of the Piezoelectric Vibrating Piece **630**

[0053] FIG. **8**(*a*) is a perspective view of the piezoelectric vibrating piece **630** on the surface at the −Y'-axis side. The piezoelectric vibrating piece **630** includes two extruding parts **637** instead of the depressed portions **137** in the piezoelectric vibrating piece **130** (see FIG. **4**(*a*)). The two extruding parts **637** protrude from the framing portion **132** in the −Y'-axis direction on the surface at the −Y'-axis side extending parallel with one another in the X-axis direction.

[0054] FIG. **8**(*b*) is a cross-sectional view of the piezoelectric device **600**. The piezoelectric device **600** includes the lid plate **110**, a base plate **220**, and the piezoelectric vibrating piece **630**. FIG. **8**(*b*) illustrates a cross-sectional view including a cross section taken along the line F-F of FIG. **8**(*a*). The base plate **220** has the same shape as the base plate **120** (see FIG. **1**) excluding an electrode. A pair of mounting terminals **224** is formed at the base plate **220** on the surface at the −Y'-axis side. A castellation electrode **225** is formed at the castellation **126**. The castellation electrode **225** electrically connects to the mounting terminal **224** and the extraction electrode **135**. With the piezoelectric device **600**, forming an electrode on the base plate after bonding of the piezoelectric vibrating piece **630** and the base plate **220** electrically connects the extraction electrode **135** and the castellation electrode **225**.

[0055] FIG. **8**(*c*) is a cross-sectional view of the piezoelectric device **600**. FIG. **8**(*c*) is a cross-sectional view including a cross section taken along the line G-G of FIG. **8**(*a*). Forming the extruding part **637** at the first framing body **132***a* of the piezoelectric vibrating piece **630** expands the surface area of the extraction electrode **135** formed at the first framing body **132***a* on the surface at the −Y'-axis side. Since this widens the extraction electrode **135**, which is formed on the first framing body **132***a* on the surface at the −Y'-axis side, relative to a current flowing in the X-axis direction, an electrical resistance is reduced relative to the current flowing in the X-axis direction. Accordingly, a crystal impedance (CI) value of the piezoelectric vibrating piece **630** can be decreased.

Fourth Embodiment

[0056] An extraction electrode formed at a framing portion of a piezoelectric vibrating piece may be formed at an inner side surface of a framing portion facing a vibrator. A description will be given of a piezoelectric vibrating piece **730** where an extraction electrode is formed at the inner side surface. Like reference numerals designate corresponding or identical elements throughout the first embodiment and the fourth embodiment, and therefore such elements will not be further elaborated here.

Constitution of the Piezoelectric Vibrating Piece **730**

[0057] FIG. **9**(*a*) is a plan view of the piezoelectric vibrating piece **730** at the +Y'-axis side. The piezoelectric vibrating piece **730** includes the vibrator **131**, the framing portion **132**, and the connecting portion **133**. An extraction electrode **735** is extracted from the excitation electrode **134** formed at the vibrator **131** on the surface at the +Y'-axis side. The extraction electrode **735** is extracted to the second framing body **132***b* at the −X-axis side via the connecting portion **133**. The extraction electrode **735** is further extracted to the surface at the −Y'-axis side via a side surface electrode **735***a*. The side surface electrode **735***a* is a part of the extraction electrode **735** formed on the side surface near the −X-axis side and the +Z'-axis side of the through groove **136**. The extraction electrode **735** is formed at the −Z'-axis side of the second framing body **132***b* at the −X-axis side, at the −Z'-axis side of the first framing body **132***a*, and at the −Z'-axis side of the second framing body **132***b* at the +X-axis side at the framing portion **132** on the surface at the +Y'-axis side. The extraction electrode **735** is extracted from the surface at the −Y'-axis side via a side surface electrode **735***b*, which is a part of the extraction electrode **735**. The side surface electrode **735***b* is formed near the −Z'-axis side and the −X-axis side of the through groove **136**, at an inner side surface at the −Z'-axis side of the first framing body **132***a* facing the vibrator **131**, and at the −Z'-axis side of the inner side surface at the +X-axis side of the second framing body **132***b* facing the vibrator **131**.

[0058] FIG. **9**(*b*) is a plan view of the piezoelectric vibrating piece **730** on the surface at the −Y'-axis side viewed from the +Y'-axis side. The extraction electrode **735** is extracted from the excitation electrode **134** formed in the vibrator **131** at the −Y'-axis side. The extraction electrode **735** is formed to

the corner at the +X-axis side and the −Z'-axis side of the framing portion **132** through the connecting portion **133** and the first framing body **132***a* at the −Z'-axis side. The extraction electrode **735** is further extracted to the framing portion **132** on the surface at the +Y'-axis side via the side surface electrode **735***b*. The extraction electrode **735** is also extracted from the surface at the +Y'-axis side to the −X-axis side and the +Z'-axis side of the framing portion **132** on the surface at the −Y'-axis side via the side surface electrode **735***a*.

[0059] FIG. **10**(*a*) is a perspective view of the piezoelectric vibrating piece **730**. The extraction electrode **735** is extracted from the excitation electrode **134**, which is formed on the surface at the +Y'-axis side, to the −X-axis side and the +Z'-axis side of the framing portion **132** on the surface at the −Y'-axis side via the side surface electrode **735***a*. The extraction electrode **735** is also extracted from the excitation electrode **134** formed on the surface at the −Y'-axis side. The extraction electrode **735** passes through the connecting portion **133**, the second framing body **132***b* at the −X-axis side, and the first framing body **132***a* at the −Z'-axis side and is formed to the corner at the +X-axis side and the −Z'-axis side on the surface at the −Y'-axis side of the framing portion **132**. With the piezoelectric vibrating piece **730**, the extraction electrode **735** is formed from the excitation electrode **134** to a connection position with the connecting electrode **123** (see FIG. **1**) across the entire framing portion **132** excluding an outer side surface. The surface area of the extraction electrode **735** is expanded.

[0060] FIG. **10**(*b*) is a cross-sectional view of a piezoelectric device **700**. FIG. **10**(*b*) is a cross-sectional view including a cross section taken along the line H-H of FIG. **10**(*a*). The piezoelectric device **700** includes the lid plate **110**, the base plate **120**, and the piezoelectric vibrating piece **730**. The extraction electrode **735**, which is formed on the first framing body **132***a* at the −Z'-axis side of the piezoelectric vibrating piece **730**, is formed at the inner side surface at the −Y'-axis side, the +Y'-axis side, and the +Z'-axis side of the first framing body **132***a*. This expands the area of the extraction electrode **735** relative to a current flowing in the X-axis direction, decreasing an electrical resistance. Accordingly, a crystal impedance (CI) of the piezoelectric vibrating piece **730** can be decreased.

[0061] With the piezoelectric vibrating piece **730**, forming the extraction electrode **735** at the inner side surface of the framing portion **132** facing the vibrator **131** or similar member expands the surface area of the extraction electrode **735**. Accordingly, the crystal impedance (CI) of the piezoelectric vibrating piece **730** can be decreased. With the piezoelectric vibrating piece **730**, the extraction electrode **735** is also formed on the first framing body **132***a* at the −Z'-axis side on the surface at the +Y'-axis side or similar region. Simply forming the side surface electrode **735***b* in addition to the framing portion **132** on the surface at the −Y'-axis side also expands the surface area of the extraction electrode **735**, decreasing the crystal impedance (CI) of the piezoelectric vibrating piece **730**.

Fifth Embodiment

[0062] A piezoelectric vibrating piece may be formed in combination with the features of the piezoelectric vibrating pieces according to the first embodiment to the third embodiment and the fourth embodiment. A description will be given of a piezoelectric vibrating piece **830** and a piezoelectric vibrating piece **930** where an extraction electrode is formed at an inner side surface and a depressed portion is formed. Like reference numerals designate corresponding or identical elements throughout the first embodiment to the fourth embodiment and the fifth embodiment, and therefore such elements will not be further elaborated here.

Constitution of the Piezoelectric Vibrating Piece **830**

[0063] FIG. **11**(*a*) is a plan view of the piezoelectric vibrating piece **830** on the surface at the +Y'-axis side. The piezoelectric vibrating piece **830** is a piezoelectric vibrating piece where a depressed portion **837** is formed at the framing portion **132** of the piezoelectric vibrating piece **730**. The piezoelectric vibrating piece **830** includes the two depressed portions **837** on the respective first framing bodies **132***a* at the +Z'-axis side and the −Z'-axis side on the surface at the +Y'-axis side. Each depressed portion **837** extends in the X-axis direction. The depressed portions **837** formed at the +Z'-axis side of the first framing body **132***a* and the depressed portions **837** formed at the −Z'-axis side of the first framing body **132***a* are disposed to be a mirror symmetry with respect to a straight line, which passes through the center of the piezoelectric vibrating piece **830**, in parallel with the X-axis.

[0064] FIG. **11**(*b*) is a plan view of the piezoelectric vibrating piece **830** on the surface at the −Y'-axis side. The piezoelectric vibrating piece **830** includes the two depressed portions **837** on the respective first framing bodies **132***a* at the +Z'-axis side and the −Z'-axis side on the surface at the −Y'-axis side. Each depressed portion **837** extends in the X-axis direction. The depressed portions **837** formed at the +Z'-axis side of the first framing body **132***a* and the depressed portions **837** formed at the −Z'-axis side of the first framing body **132***a* are disposed to be a mirror symmetry with respect to a straight line, which passes through the center of the piezoelectric vibrating piece **830**, in parallel with the X-axis. Additionally, the depressed portions **837** formed at each first framing body **132***a* on the surfaces at the +Y'-axis side and the −Y'-axis side are formed overlapping one another in the Y'-axis direction.

[0065] With the piezoelectric vibrating piece **830**, forming the depressed portion **837** expands the surface area of the extraction electrode **735** and decreases a crystal impedance (CI) of the piezoelectric vibrating piece **830**. Further, the depressed portions **837** formed at the +Z'-axis side and the −Z'-axis side of the first framing bodies **132***a* are mirror symmetry with one another, and the depressed portions **837** formed at the +Y'-axis side and the −Y'-axis side of the first framing bodies **132***a* are formed overlapping one another. These disperse stress applied to the framing portion **132**; therefore, strength of the piezoelectric device improves and stress applied to a bonding portion between the framing portion **132** and a lid plate and a bonding portion between the framing portion **132** and a base plate disperses, thus sealing strength of a cavity improves. Forming the depressed portions symmetrically thus disperses stress applied to the piezoelectric device. Further, the piezoelectric vibrating piece **830** may include a depressed portion only either one of the +Y'-axis side and the −Y'-axis side.

Constitution of the Piezoelectric Vibrating Piece **930**

[0066] FIG. **12**(*a*) is a plan view of the piezoelectric vibrating piece **930** on the surface at the +Y'-axis side. The piezoelectric vibrating piece **930** is a piezoelectric vibrating piece where a depressed portion **937** is formed at the framing portion **132** of the piezoelectric vibrating piece **730**. The piezo-

electric vibrating piece **930** includes the two depressed portions **937** on the first framing body **132***a* at the −*Z*'-axis side on the surface at the +Y'-axis side. The depressed portions **937** extend in the X-axis direction. The two depressed portions **937** are formed at a region at the −X-axis side of the first framing body **132***a* at the +Z'-axis side where the extraction electrode **735** is formed. The depressed portions **937** extend in the X-axis direction.

[0067] FIG. **12**(*b*) is a plan view of the piezoelectric vibrating piece **930** on the surface at the −Y'-axis side. The piezoelectric vibrating piece **930** includes the two depressed portions **937** on the first framing body **132***a* at the −*Z*'-axis side on the surface at the −Y'-axis side. The depressed portions **937** extend in the X-axis direction. The two depressed portions **937** are formed at a region at the −X-axis side of the first framing body **132***a* at the +Z'-axis side where the extraction electrode **735** is formed. The depressed portions **937** extend in the X-axis direction.

[0068] With the piezoelectric vibrating piece **930**, forming the depressed portions **937** on both pair of extraction electrodes **735** expands the surface area of the extraction electrode **735**. Thus, a crystal impedance (CI) of the piezoelectric vibrating piece **930** can be decreased. Further, the piezoelectric vibrating piece **930** may include a depressed portion **937** only either one of the +Y'-axis side and the −Y'-axis side.

[0069] The piezoelectric vibrating piece **730** may include the depressed portion **137** illustrated in FIG. **3**(*b*) or the depressed portion **337** illustrated in FIG. **6**(*a*) on at least one of the surface at the +Y'-axis side or the surface at the −Y'-axis side. This decreases the crystal impedance (CI) of the piezoelectric vibrating piece and improves the strength of the piezoelectric vibrating piece or the piezoelectric device. Additionally, these depressed portions may be extruding parts.

Sixth Embodiment

[0070] The piezoelectric vibrating pieces according to the first embodiment to the third embodiment may include depressed portions or extruding parts, which are formed at the framing portion of the piezoelectric vibrating piece, on the framing portions on both surfaces at the +Y'-axis side and the −Y'-axis side. A description will be given of a piezoelectric vibrating piece **1030** where the depressed portions are formed on the framing portions on the surface at the +Y'-axis side and on the surface at the −Y'-axis side. The following embodiment describes the case where the depressed portion is formed; however, the extruding part may be formed instead of the depressed portion. Like reference numerals designate corresponding or identical elements throughout the first embodiment and the second embodiment and the sixth embodiment, and therefore such elements will not be further elaborated here.

[0071] FIG. **13**(*a*) is a plan view of the piezoelectric vibrating piece **1030**. The piezoelectric vibrating piece **1030** in FIG. **13**(*a*) includes the vibrator **131**, the framing portion **132**, and the connecting portion **133**. The framing portion **132** includes two depressed portions **1037** on the surface at the +Y'-axis side. The depressed portions **1037** are depressed from the framing portion **132** on the surface at the +Y'-axis side in the −Y'-axis direction and surround the peripheral area of the vibrator **131**. The piezoelectric vibrating piece **1030** has the surface at the −Y'-axis side the same as that in FIG. **6**(*a*). Additionally, the depressed portions **337** (see FIG. **6**(*a*)) and the depressed portion **1037** are formed overlapping one another in the Y'-axis direction.

[0072] FIG. **13**(*b*) is a cross-sectional view of the piezoelectric device **1000**. FIG. **13**(*b*) is a cross-sectional view including a cross section taken along the line K-K of FIG. **13**(*a*). The piezoelectric device **1000** includes the piezoelectric vibrating piece **1030**, the base plate **120**, and the lid plate **110**. The base plate **120** is to be bonded at the −Y'-axis side of the piezoelectric vibrating piece **1030**. The lid plate **110** is to be bonded on the surface at the +Y'-axis side of the piezoelectric vibrating piece **1030**. The piezoelectric vibrating piece **1030** includes a depressed portion **1037** at the framing portion **132** on the surface at the +Y'-axis side. The surface of the framing portion **132** at the +Y'-axis side is bonded to the bonding surface **112** of the lid plate **110** via the bonding material **140**. The piezoelectric vibrating piece **1030** includes the depressed portion **337** at the framing portion **132** on the surface at the −Y'-axis side. The surface at the −Y'-axis side of the framing portion **132** is bonded to the bonding surface **122** of the base plate **120** via the bonding material **140**.

[0073] With the piezoelectric device **1000**, the depressed portion **337** and the depressed portion **1037** are formed corresponding to the bonding surface **122** and the bonding surface **112**. This allows uniformly bonding between the framing portion **132** and the bonding surface **122** and between the framing portion **132** and the bonding surface **112** without causing unevenness in bonding strength. Accordingly, stress applied between the framing portion **132** and the bonding surface **122** does not concentrate at a specific portion but disperses. Consequently, the bonding strength between the framing portion **132** and the bonding surface **122** and between the framing portion **132** and the bonding surface **112** improves, and this also improves sealing strength of the cavity **150**. Additionally, with the piezoelectric vibrating piece **1030**, the depressed portions **337** and the depressed portions **1037** formed at the framing portions **132** are disposed to be mirror symmetry with one another at the +Z'-axis side and the −Z'-axis side of the framing portion **132** and are formed overlapping in the Y'-axis direction of the framing portion **132**. This disperses stress applied to the framing portion **132**, and therefore the strength of the piezoelectric device is increased.

[0074] Representative embodiments are described in detail above; however, as will be evident to those skilled in the relevant art, this disclosure may be changed or modified in various ways within its technical scope.

[0075] For example, a plurality of the above-described embodiments may be employed in combination. This may further decrease a crystal impedance (CI). The above-described embodiments disclose the case where two depressed portions and two extruding parts are employed. However, a single or equal to or more than three depressed portions and extruding parts may be employed. Additionally, the above-described embodiments disclose a case where the piezoelectric vibrating piece is an AT-cut quartz-crystal vibrating piece. A BT-cut quartz-crystal vibrating piece or similar member that similarly vibrates in the thickness-shear mode is similarly applicable. Further, the piezoelectric vibrating piece is basically applicable to a piezoelectric material that includes not only a quartz-crystal material but also lithium tantalate, lithium niobate, and piezoelectric ceramics.

[0076] The piezoelectric device according to the above-described embodiments may include a grounding terminal that grounds the piezoelectric device or similar member as

well as a mounting terminal. Additionally, the piezoelectric device can include an integrated circuit and be formed as a piezoelectric oscillator.

[0077] In the first aspect of the disclosure, the piezoelectric vibrating piece according to a second aspect is configured as follows. The extraction electrode is disposed via the second framing body. The depressed portion or the extruding part is also disposed on a region of the second framing body where the extraction electrode is formed.

[0078] In the first aspect and the second aspect of the disclosure, the piezoelectric vibrating piece according to a third aspect is configured as follows. The depressed portion or the extruding part surrounds the vibrator at the framing body on the one principal surface.

[0079] In the first aspect to the third aspect of the disclosure, the piezoelectric vibrating piece according to a fourth aspect is configured as follows. A plurality of the depressed portions or the extruding parts is disposed on the first framing body.

[0080] In the first aspect to the fourth aspect of the disclosure, the piezoelectric vibrating piece according to a fifth aspect is configured as follows. The extraction electrode is extracted from the excitation electrode formed on the one principal surface.

[0081] In the first aspect to the fifth aspect of the disclosure, the piezoelectric vibrating piece according to a sixth aspect is configured as follows. The extraction electrode is also disposed at an inner side surface of the first framing body facing the vibrator.

[0082] In the first aspect to the sixth aspect of the disclosure, the piezoelectric vibrating piece according to a seventh aspect is configured as follows. The vibrator includes a mesa portion and a peripheral portion on at least one of the principal surfaces. The mesa portion is disposed at a center of the principal surface. The excitation electrode is disposed on the mesa portion. The peripheral portion is a region other than the mesa portion. The peripheral portion is thinner than the mesa portion. The mesa portion has a step height from the peripheral portion. The step height is equal to a depth of the depressed portion or a height of the extruding part.

[0083] The piezoelectric vibrating piece according to an eighth aspect is configured as follows. A vibrator has a rectangular shape and vibrates at a predetermined vibration frequency. The vibrator includes excitation electrodes on both principal surfaces. A framing portion surrounds a peripheral area of the vibrator. The framing portion includes a pair of first framing bodies and a pair of second framing bodies. The pair of first framing bodies extends in a long side direction. The pair of second framing bodies extends in a short side direction. A connecting portion connects the vibrator and the one second framing body. An extraction electrode is extracted from the excitation electrode on the one principal surfaces via the one principal surface of the connecting portion, one of the second framing bodies on the one principal surface, and one of the first framing bodies on the one principal surface. The extraction electrode is extracted to another of the second framing bodies on the one principal surface. The extraction electrode is disposed on an entire surface of an inner side surface of one of the one first framing bodies facing the vibrator, the inner side surface of the connecting portion, and the inner side surface of one of the second framing bodies.

[0084] In the eighth aspect of the disclosure, the piezoelectric vibrating piece according to a ninth aspect is configured as follows. The extraction electrode is further disposed on another principal surface of the connecting portion, another principal surface of the one of the second framing bodies, and another principal surface of the one of the first framing bodies.

[0085] A piezoelectric device according to a tenth aspect is configured as follows. The piezoelectric vibrating piece is according to the first aspect to the ninth aspect of the disclosure. A base plate is bonded on one principal surface of the framing portion. A lid plate is bonded on another principal surface of the framing portion to seal the vibrator.

[0086] With the piezoelectric vibrating piece and the piezoelectric device according to the embodiments, expanding a surface area of an extraction electrode formed at a framing portion allows lowering an electrical resistance of the extraction electrode.

[0087] The principles, preferred embodiment and mode of operation of the present invention have been described in the foregoing specification. However, the invention which is intended to be protected is not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. Variations and changes may be made by others, and equivalents employed, without departing from the spirit of the present invention. Accordingly, it is expressly intended that all such variations, changes and equivalents which fall within the spirit and scope of the present invention as defined in the claims, be embraced thereby.

What is claimed is:

1. A piezoelectric vibrating piece, comprising:

a vibrator, having a rectangular shape, the vibrator vibrating at a predetermined vibration frequency, the vibrator including excitation electrodes on both principal surfaces;

a framing portion, surrounding a peripheral area of the vibrator, the framing portion including a first framing body and a second framing body, the first framing body extending in a long side direction, the second framing body extending in a short side direction; and

a connecting portion, connecting the vibrator and the framing portion, wherein

the first framing body includes a depressed portion or an extruding part on one principal surface, the depressed portion or the extruding part extending in a long side direction, and

the piezoelectric vibrating piece further includes an extraction electrode extending from the excitation electrode via the connecting portion, the extraction electrode extending from one end to another end of the one principal surface of the first framing body, the first framing body including the depressed portion or the extruding part.

2. The piezoelectric vibrating piece according to claim **1**, wherein

the extraction electrode is disposed via the second framing body, and

the depressed portion or the extruding part is also disposed on a region of the second framing body where the extraction electrode is formed.

3. The piezoelectric vibrating piece according to claim **1**, wherein

the depressed portion or the extruding part surrounds the vibrator at the framing body on the one principal surface.

4. The piezoelectric vibrating piece according to claim **1**, wherein

a plurality of the depressed portions or the extruding parts is disposed on the first framing body.

5. The piezoelectric vibrating piece according to claim **1**, wherein

the extraction electrode is extracted from the excitation electrode formed on the one principal surface.

6. The piezoelectric vibrating piece according to claim **1**, wherein

the extraction electrode is also disposed at an inner side surface of the first framing body facing the vibrator.

7. The piezoelectric vibrating piece according to claim **1**, wherein

the vibrator includes a mesa region and a peripheral region on at least one of the principal surfaces, the mesa region being disposed at a center of the principal surface, the excitation electrode being disposed on the mesa region, the peripheral region being a region other than the mesa region, the peripheral region being thinner than the mesa region, and

the mesa region has a step height from the peripheral region, the step height being equal to a depth of the depressed portion or a height of the extruding part.

8. A piezoelectric vibrating piece, comprising:

a vibrator, having a rectangular shape, the vibrator vibrating at a predetermined vibration frequency, the vibrator including excitation electrodes on both principal surfaces;

a framing portion, surrounding a peripheral area of the vibrator, the framing portion including a pair of first framing bodies and a pair of second framing bodies, the pair of first framing bodies extending in a long side direction, the pair of second framing bodies extending in a short side direction;

a connecting portion, connecting the vibrator and the one second framing body; and

an extraction electrode, being extracted from the excitation electrode on the one principal surfaces via the one principal surface of the connecting portion, one of the second framing bodies on the one principal surface, and one of the first framing bodies on the one principal surface, the extraction electrode being extracted to another of the second framing bodies on the one principal surface, wherein

the extraction electrode is disposed on an entire surface of an inner side surface of one of the first framing bodies facing the vibrator, the inner side surface of the connecting portion, and the inner side surface of one of the second framing bodies.

9. The piezoelectric vibrating piece according to claim **8**, wherein

the extraction electrode is further disposed on another principal surface of the connecting portion, another principal surface of the one of the second framing bodies, and another principal surface of the one of the first framing bodies.

10. A piezoelectric device, comprising:

the piezoelectric vibrating piece according to claim **1**;

a base plate, being bonded on one principal surface of the framing portion; and

a lid plate, being bonded on another principal surface of the framing portion to seal the vibrator.

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