US 20250259782A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0259782 A1
(43) Pub. Date: Aug. 14, 2025
TAKAMATSU et al.

(54) INDUCTOR COMPONENT

(71) Applicant: **Murata Manufacturing Co., Ltd.**, Kyoto-fu (JP)

(72) Inventors: **Tsuyoshi TAKAMATSU**, Nagaokakyo-shi (JP); **Yoshimasa YOSHIOKA**, Nagaokakyo-shi (JP); **Hideki KAMO**, Nagaokakyo-shi (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**, Kyoto-fu (JP)

(21) Appl. No.: **19/195,304**

(22) Filed: **Apr. 30, 2025**

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2023/030314, filed on Aug. 23, 2023.

(30) **Foreign Application Priority Data**

Nov. 2, 2022 (JP) 2022-176448

Publication Classification

(51) **Int. Cl.**
H01F 27/29 (2006.01)
H01F 17/00 (2006.01)

(52) **U.S. Cl.**
CPC *H01F 27/292* (2013.01); *H01F 17/0013* (2013.01)

(57) **ABSTRACT**

An inductor component includes an element body having first and second principal surfaces opposite to each other; a coil that is in the element body and is wound in a spiral shape along an axis; and first and second external electrodes that are on the element body and are electrically connected to the coil. The axis of the coil is parallel to the first principal surface. The coil includes first coil wirings which are on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, second coil wirings which are on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, and first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings.

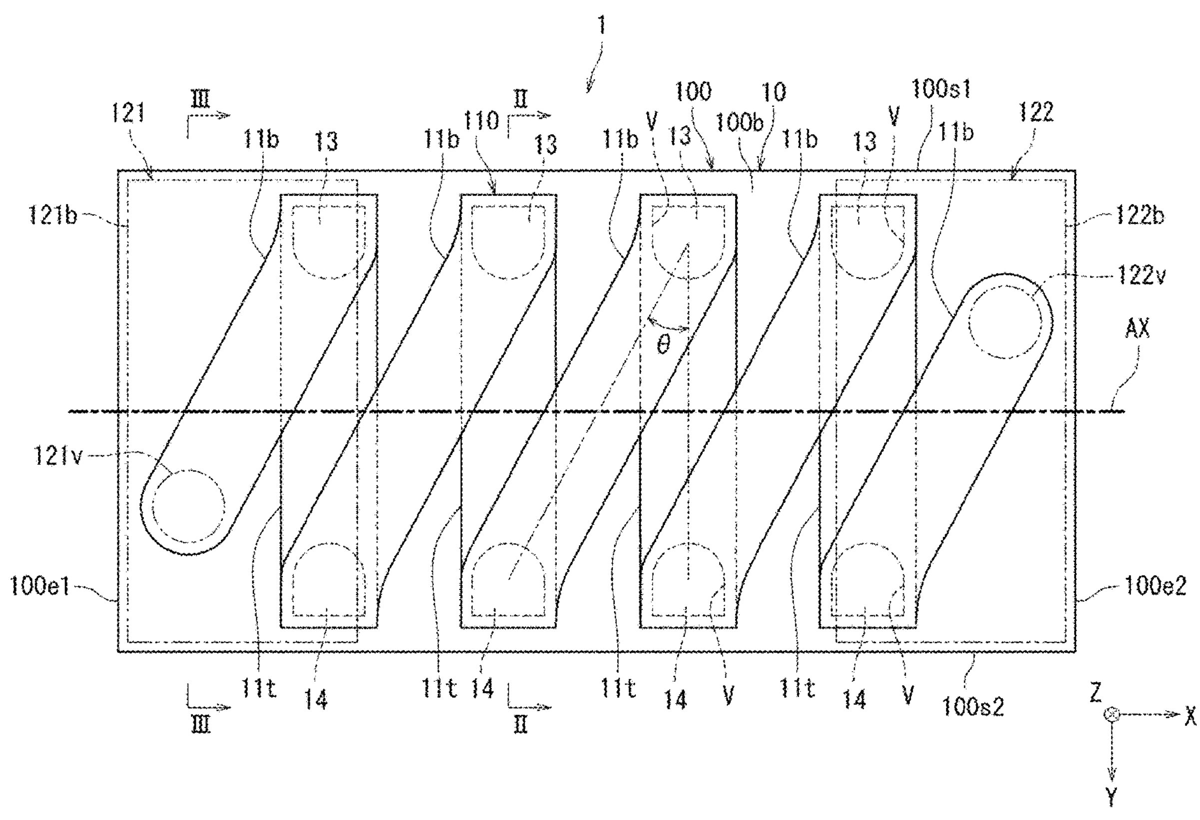


Fig. 1

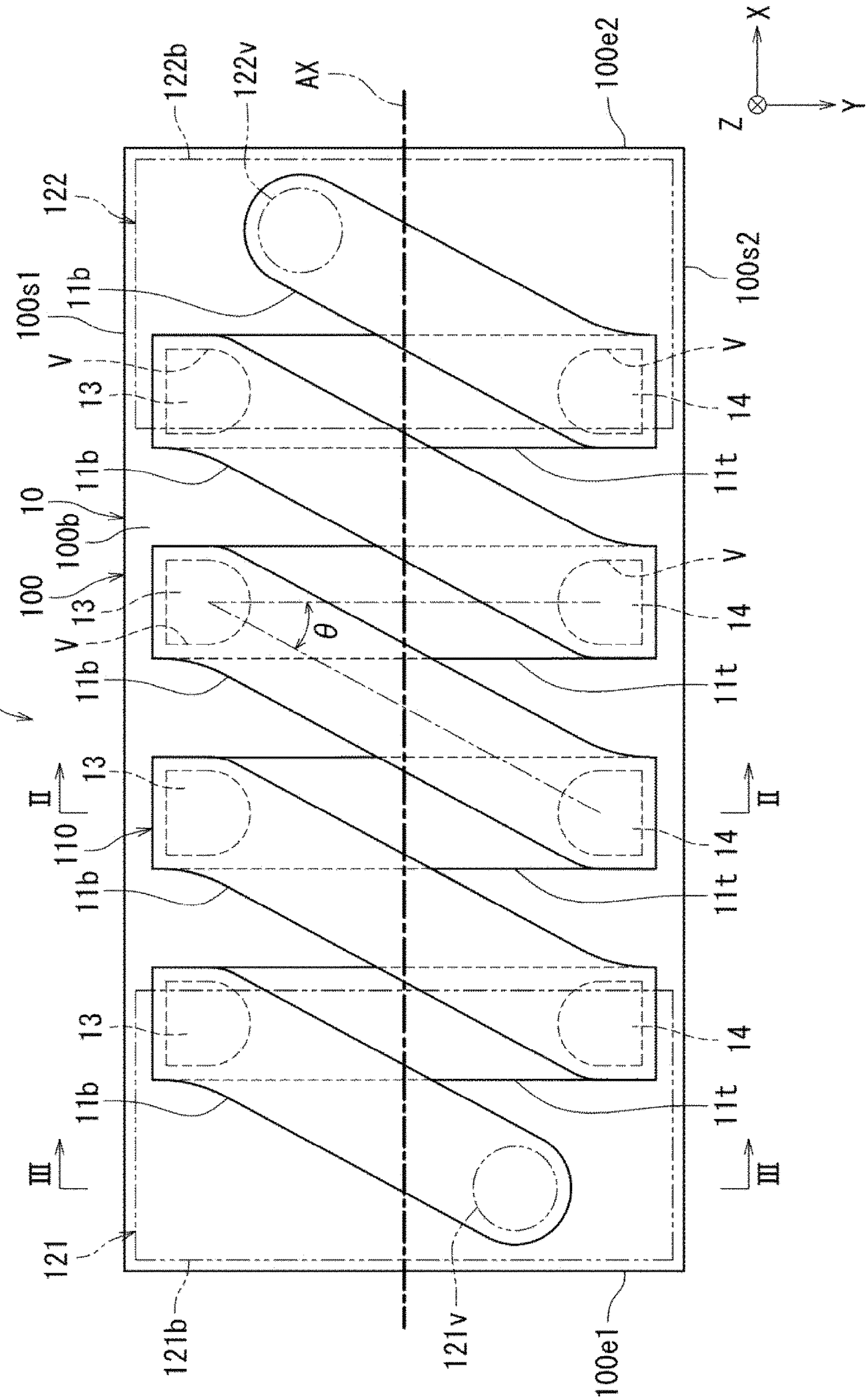

1
10
100
100b
100e1
100e2
100s1
100s2
110
11b
11t
13
14
V
θ
121
121b
121v
122
122b
122v
AX
II
III
X
Y
Z

Fig. 2

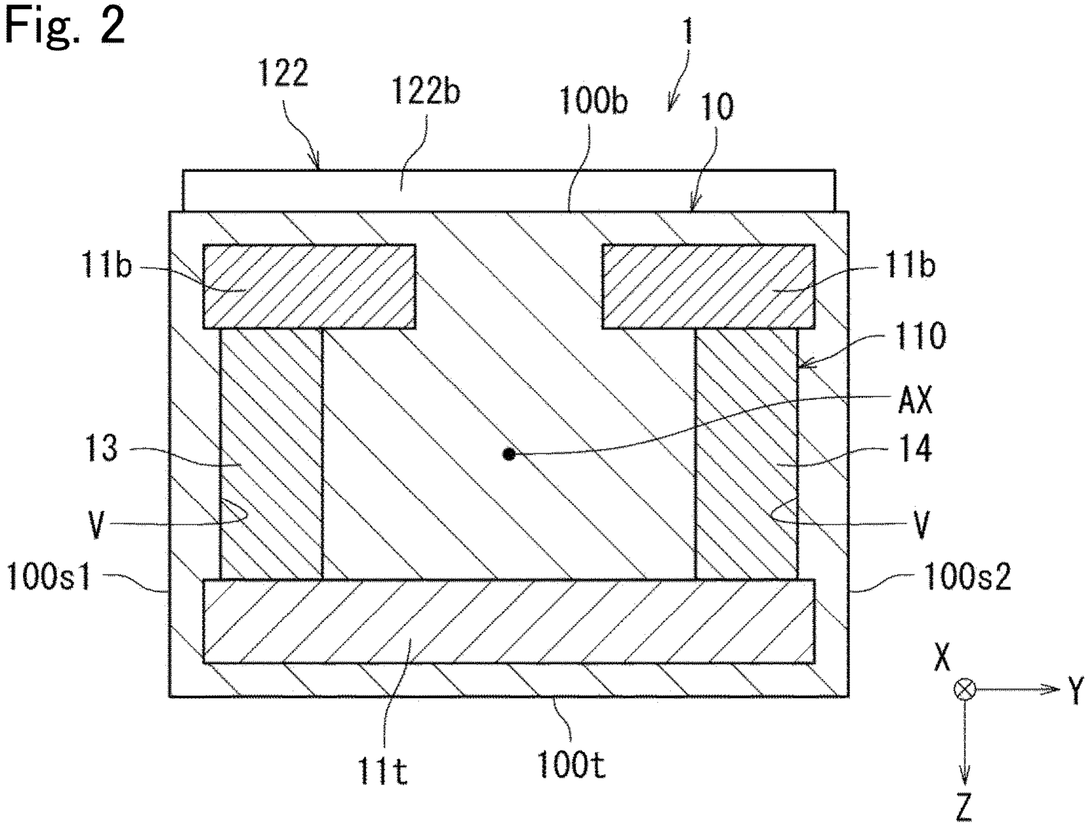

1
122
122b
100b
10
11b
11b
110
AX
13
14
V
V
100s1
100s2
11t
100t
X
Y
Z

Fig. 3

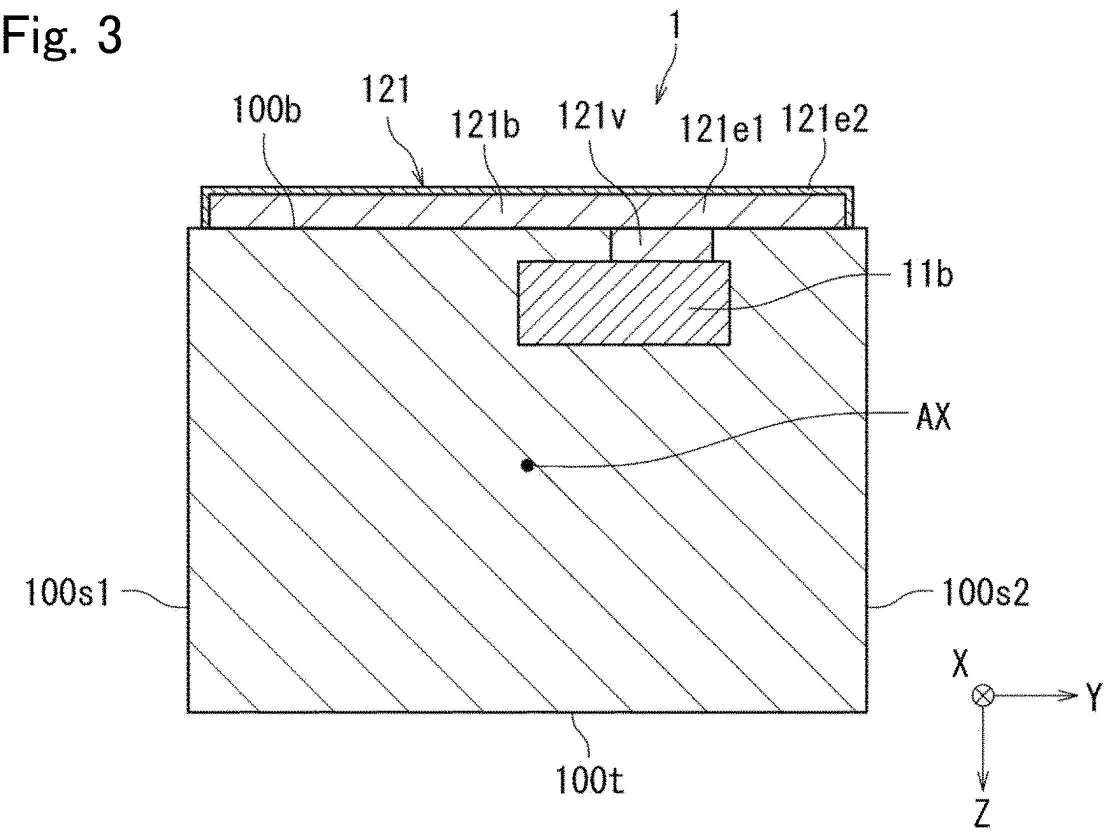

1
121
100b
121b
121v
121e1
121e2
11b
AX
100s1
100s2
100t
X
Y
Z

Fig. 4

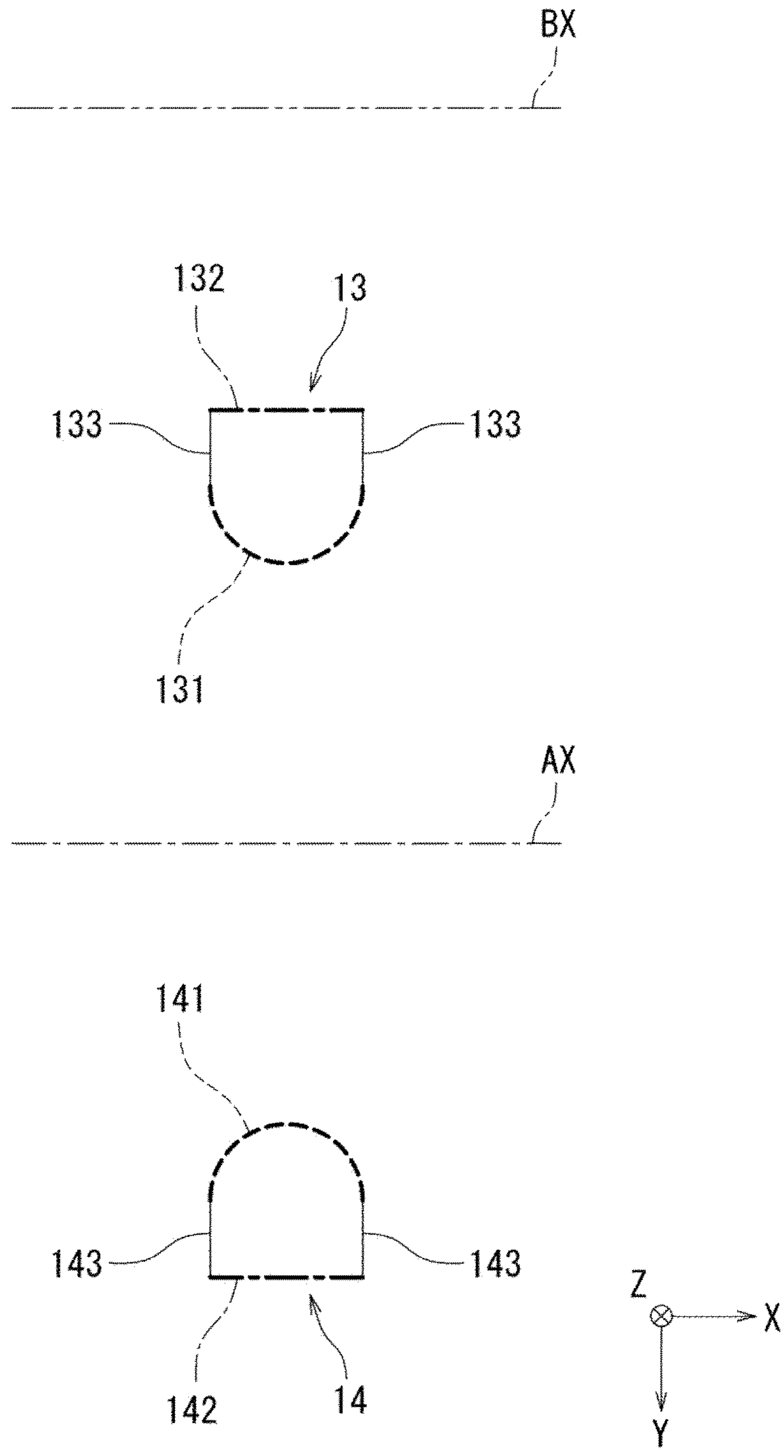


Fig. 5

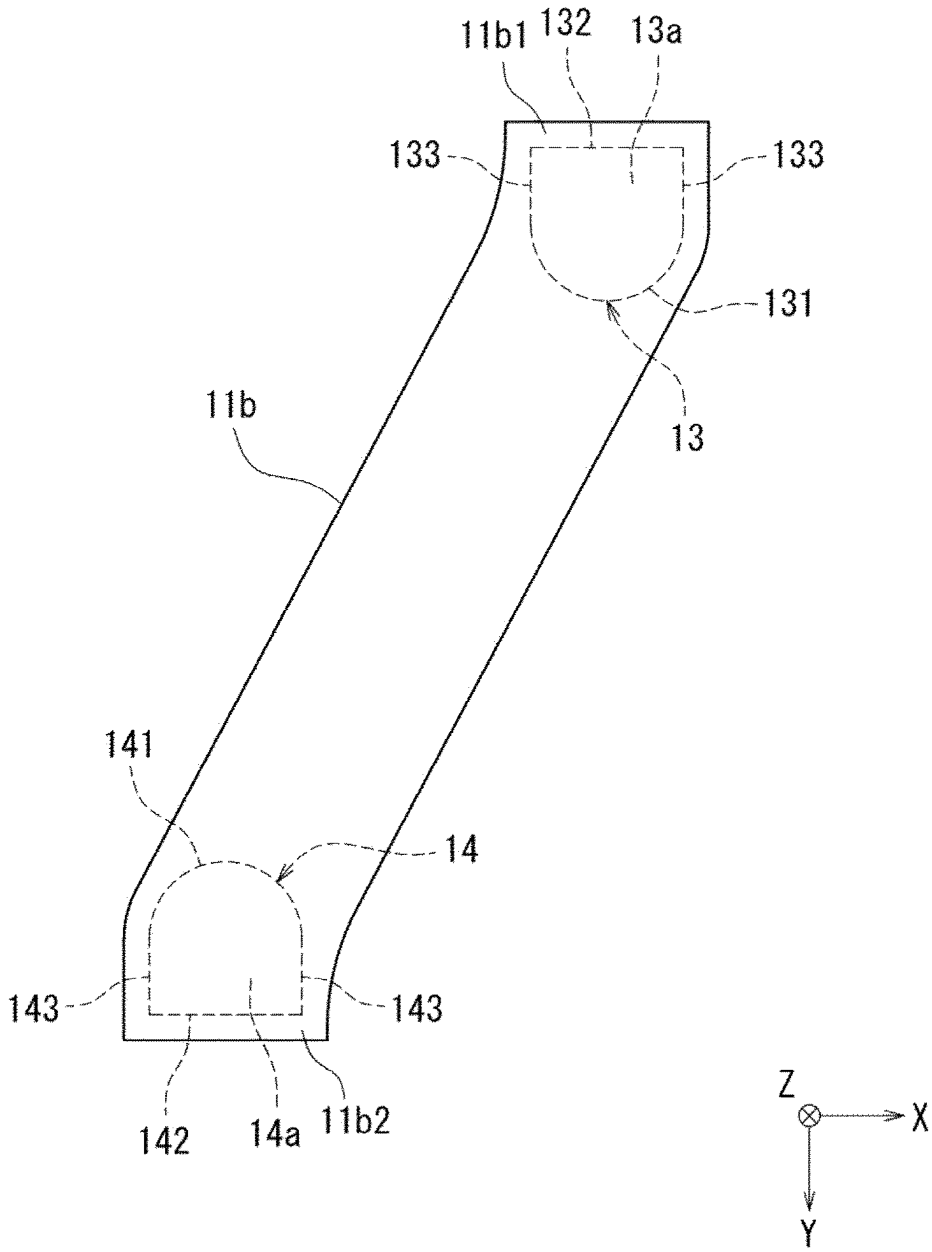


Fig. 6A

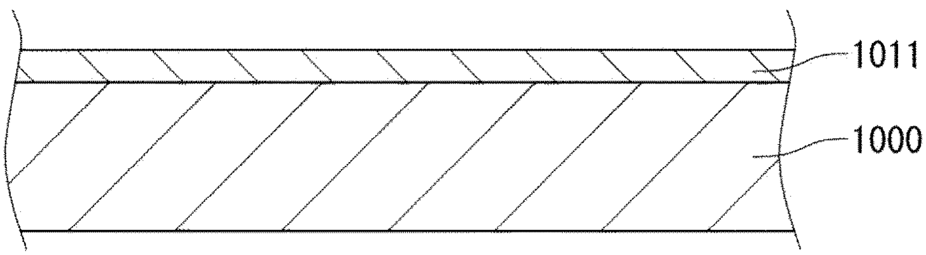


Fig. 6B

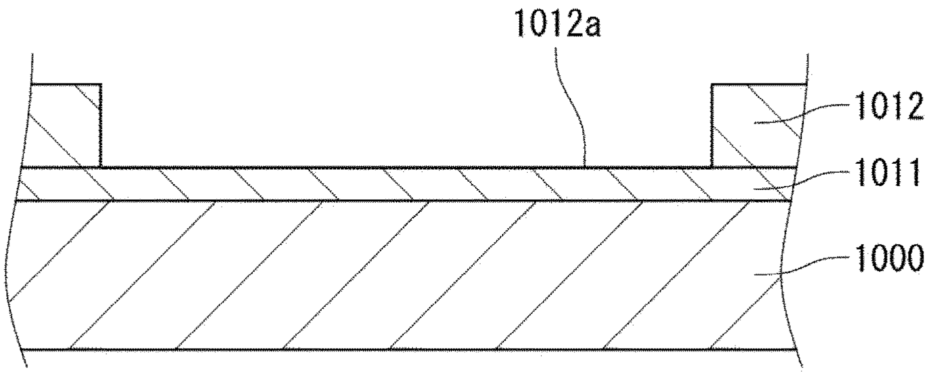


Fig. 6C

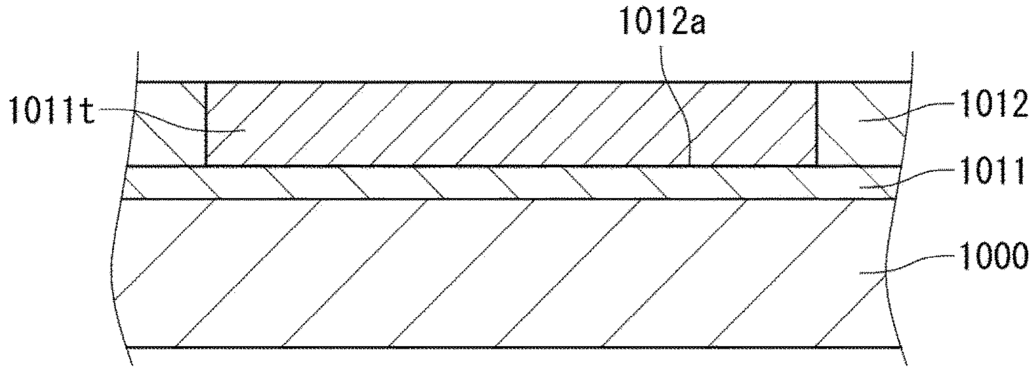


Fig. 6D

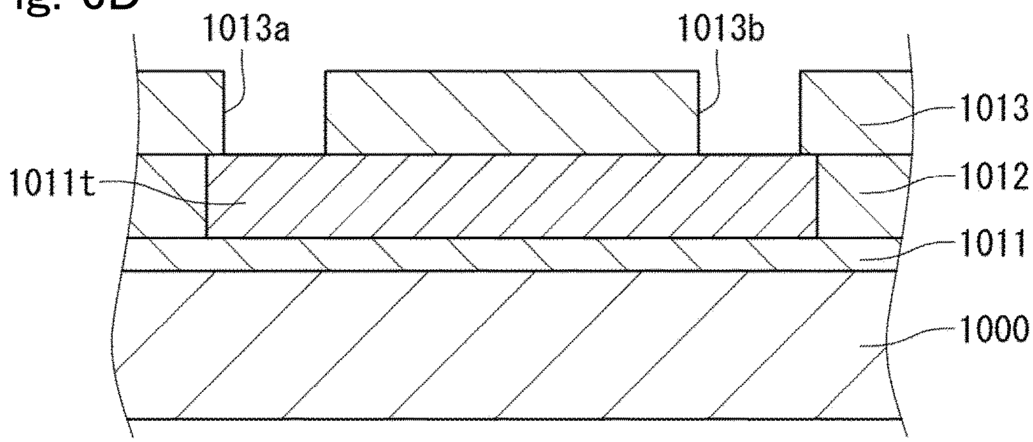


Fig. 6E

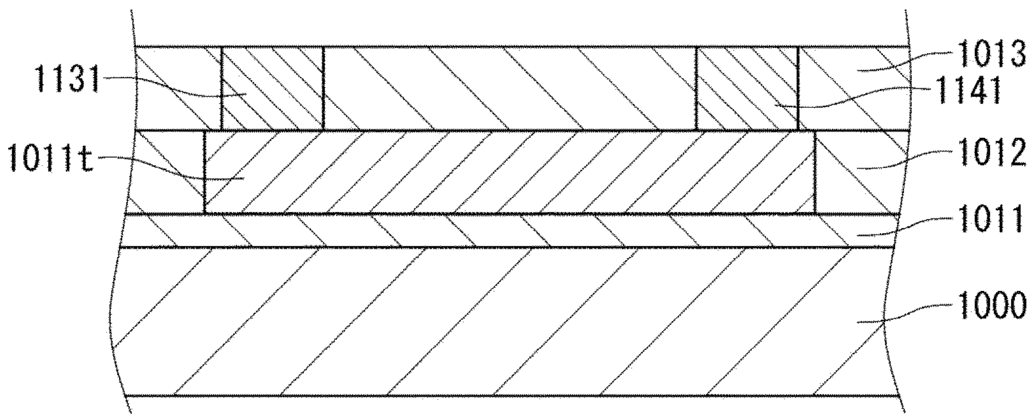


Fig. 6F

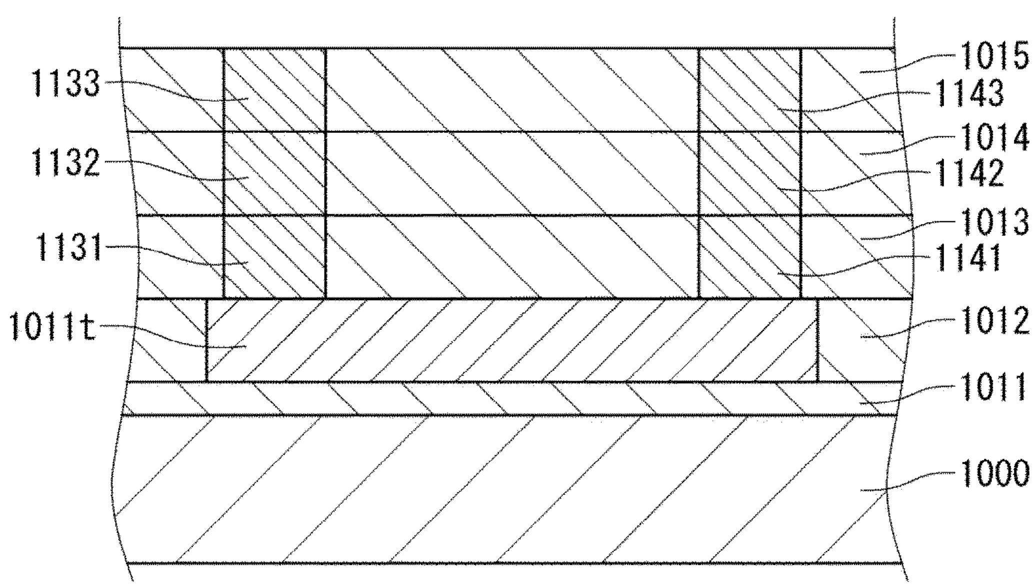


Fig. 6G

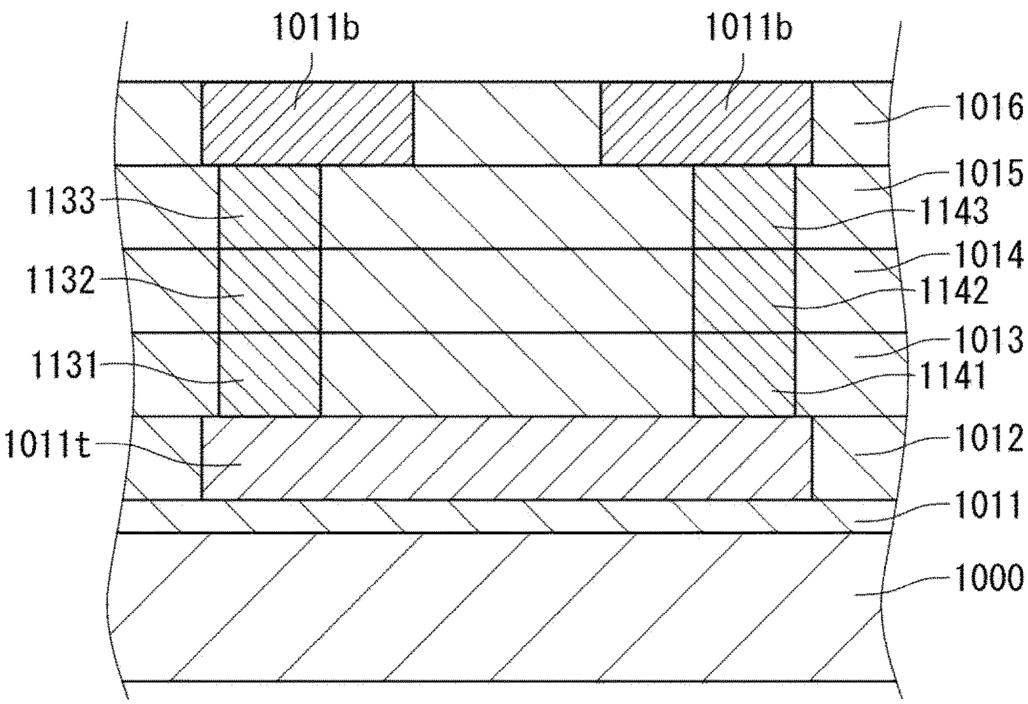

1011b
1011b
1016
1015
1133
1143
1014
1132
1142
1013
1131
1141
1011t
1012
1011
1000

Fig. 6H

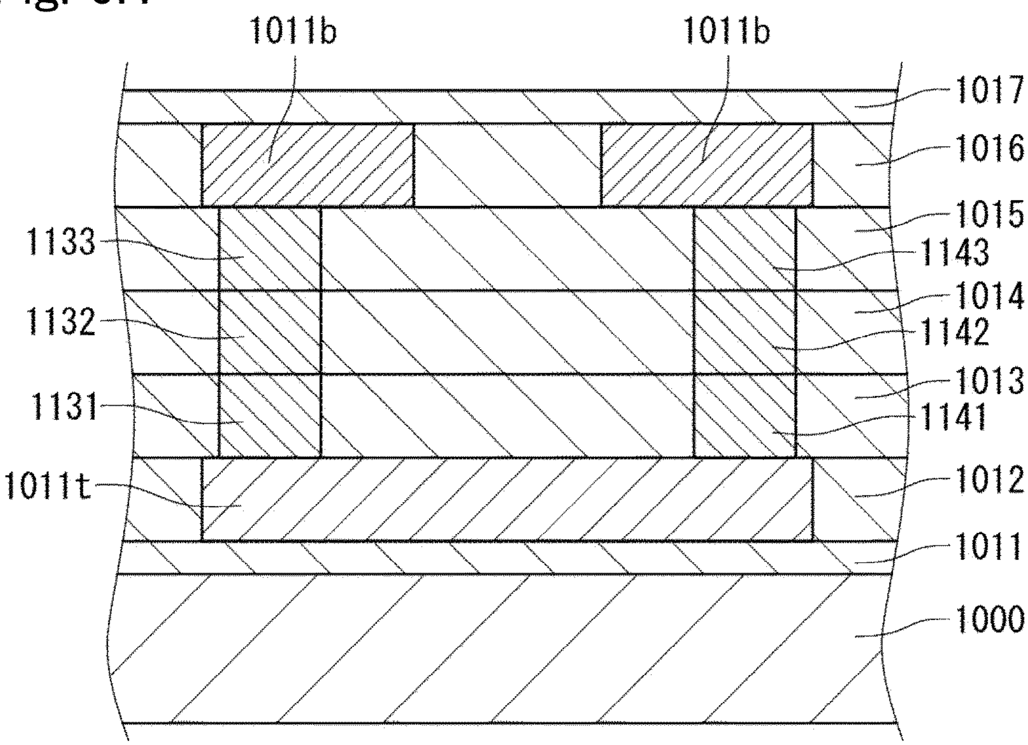
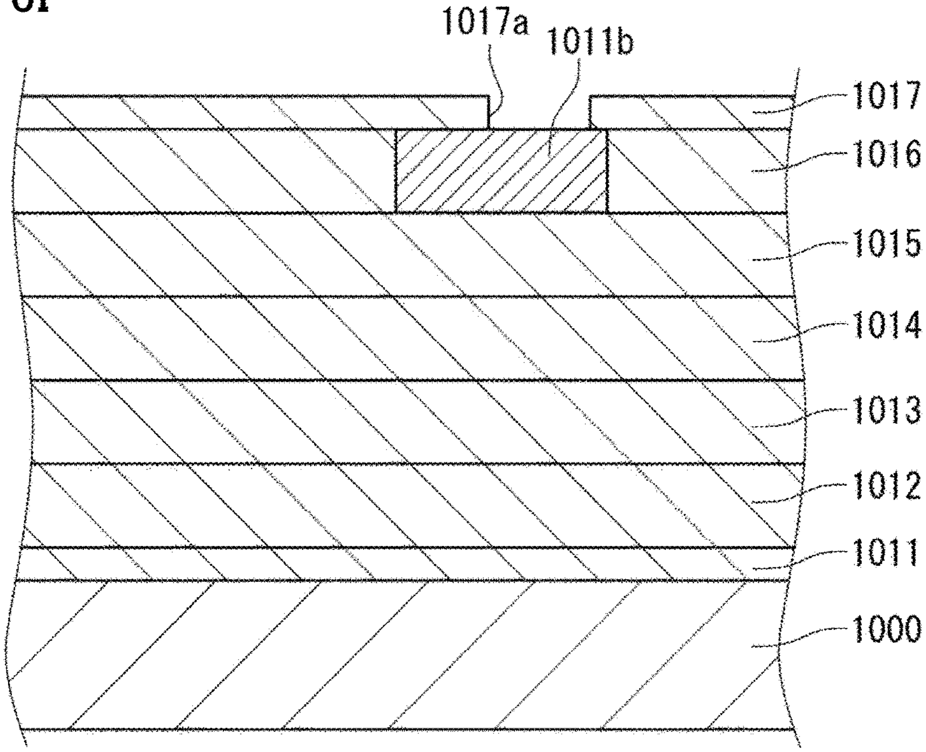
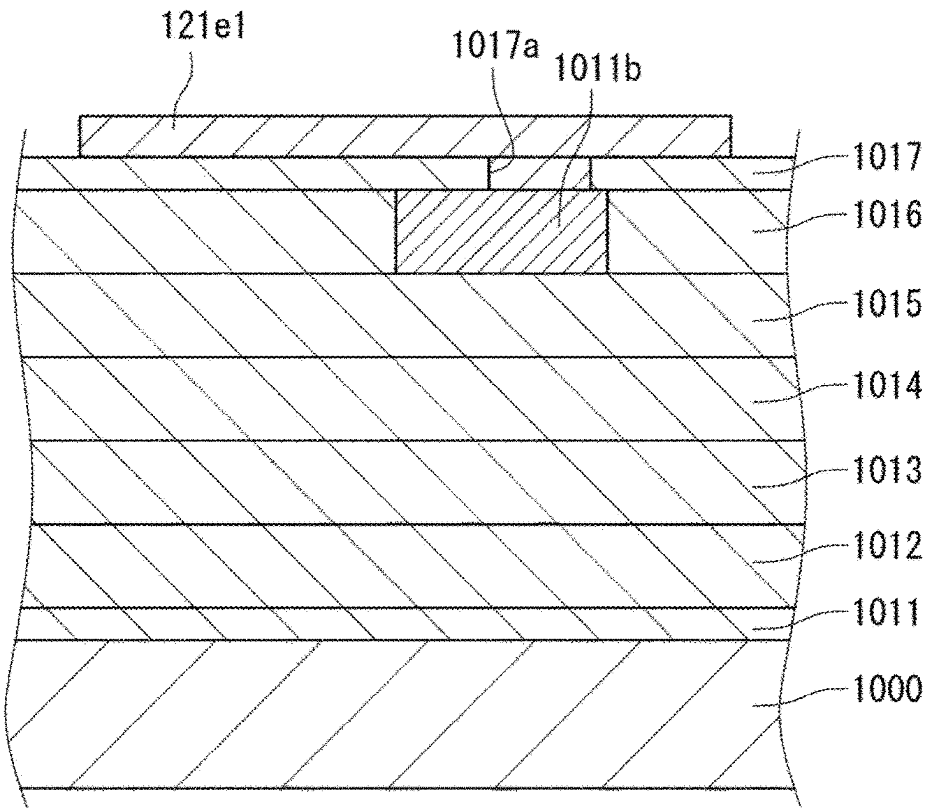

1011b
1011b
1017
1016
1015
1133
1143
1014
1132
1142
1013
1131
1141
1011t
1012
1011
1000

Fig. 6I



1017a
1011b
1017
1016
1015
1014
1013
1012
1011
1000

Fig. 6J



121e1
1017a
1011b
1017
1016
1015
1014
1013
1012
1011
1000

Fig. 6K

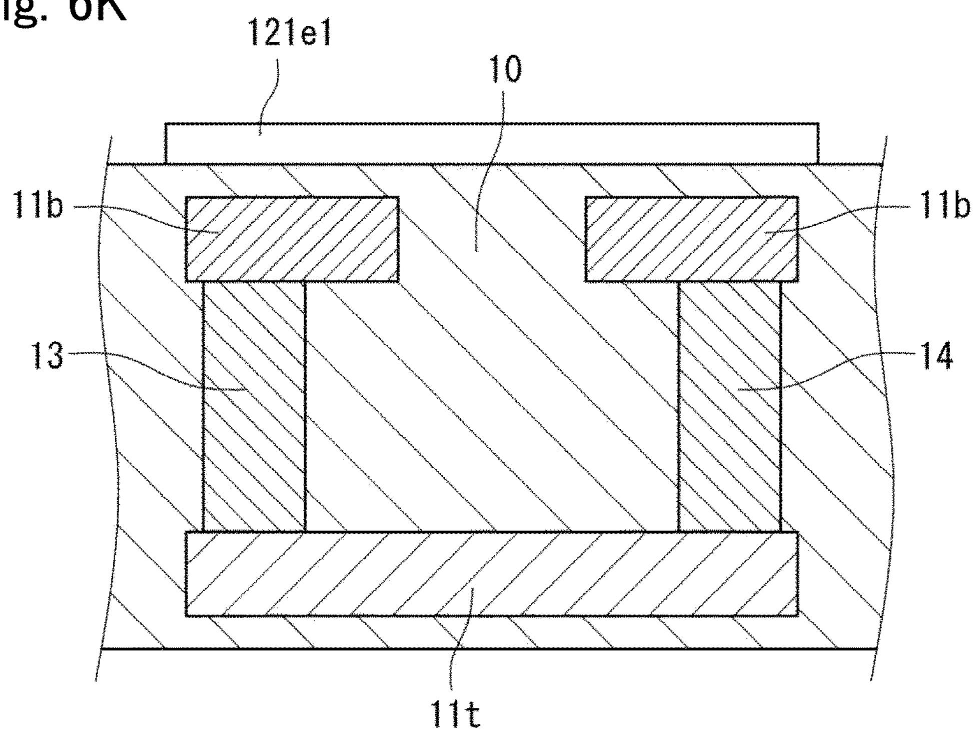


Fig. 6L

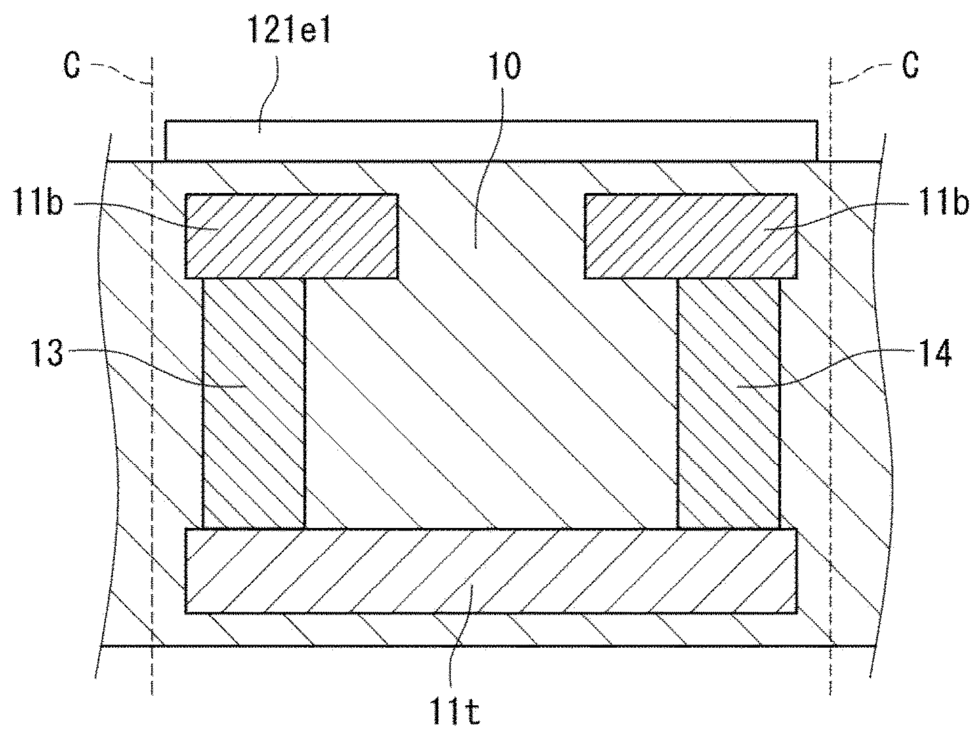


Fig. 6M

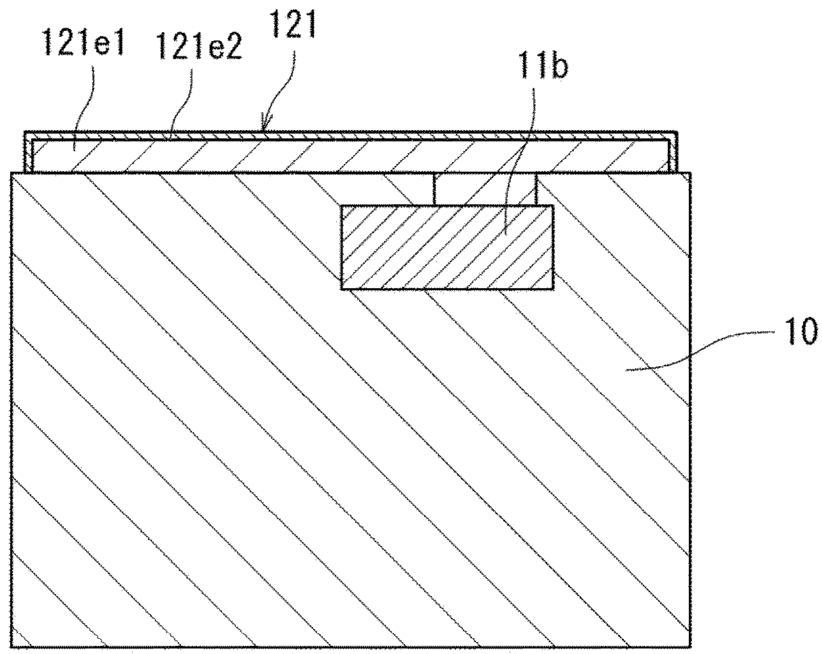


Fig. 7A

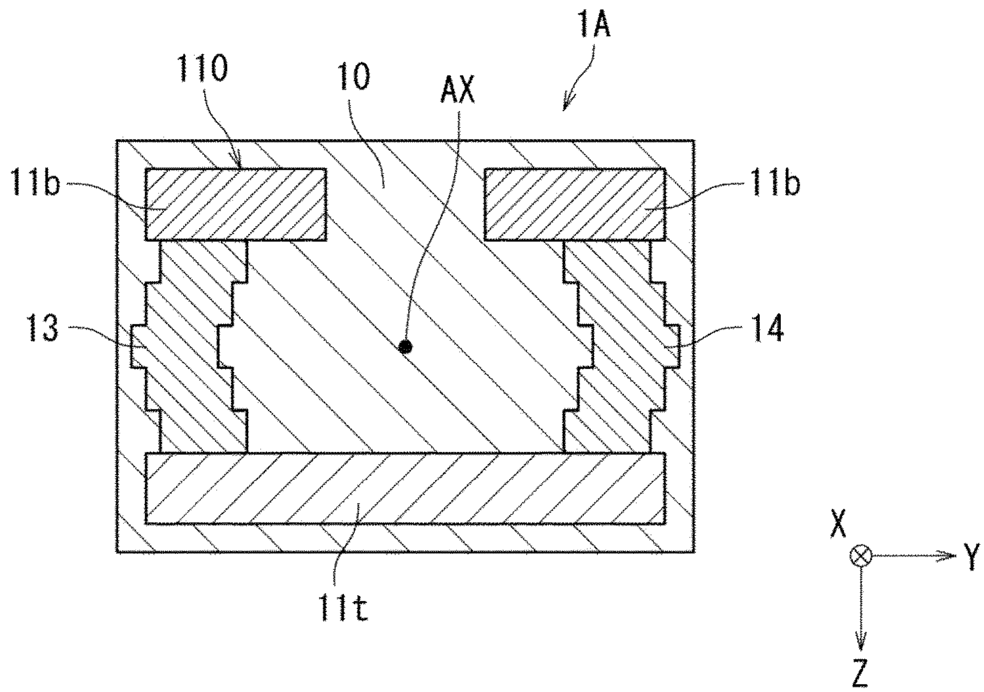


Fig. 7B

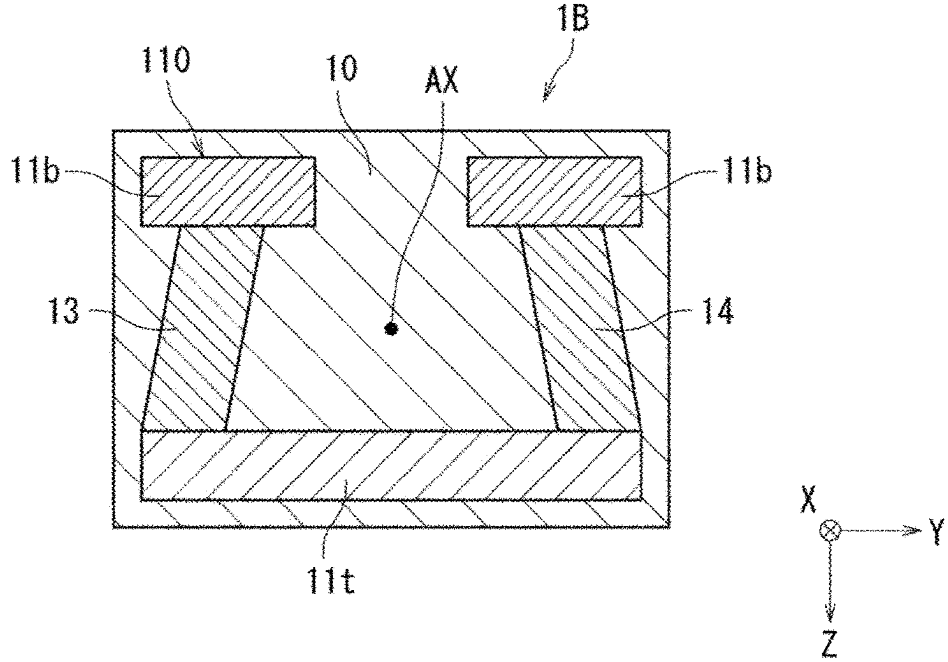

1B
110
10
AX
11b
11b
13
14
11t
X
Y
Z

Fig. 7C

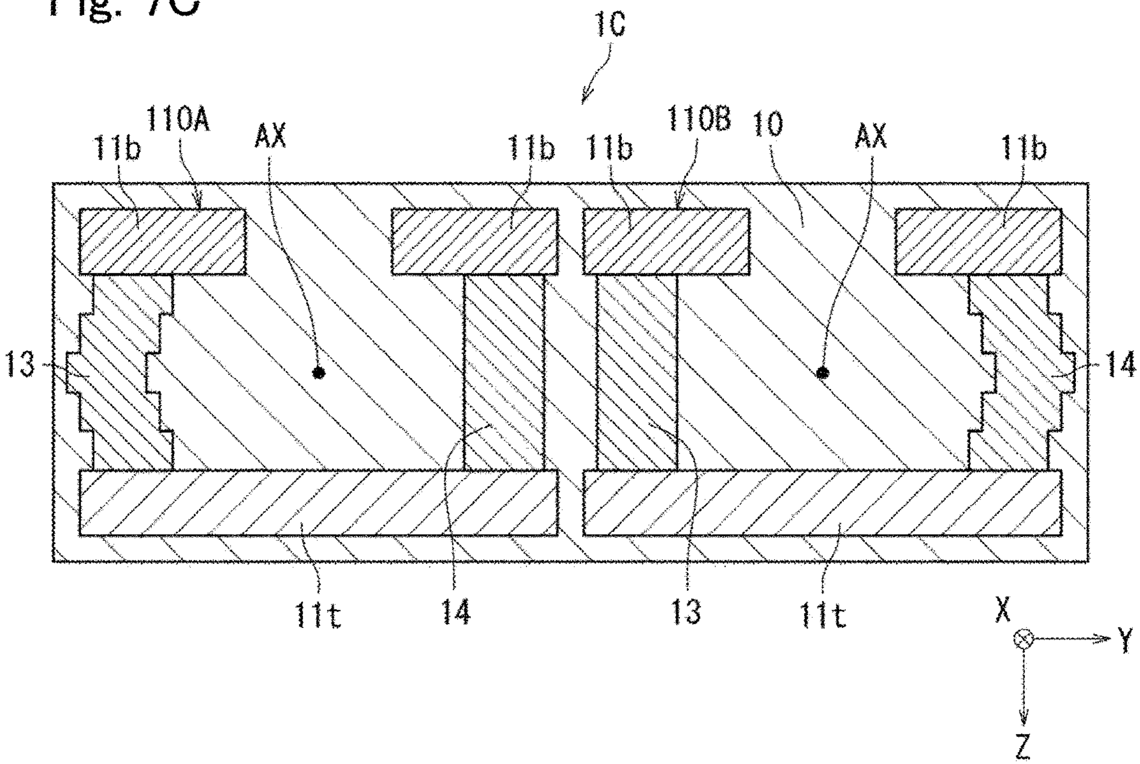

1C
110A
AX
11b
11b
11b
110B
10
AX
11b
13
14
11t
14
13
11t
X
Y
Z

Fig. 7D

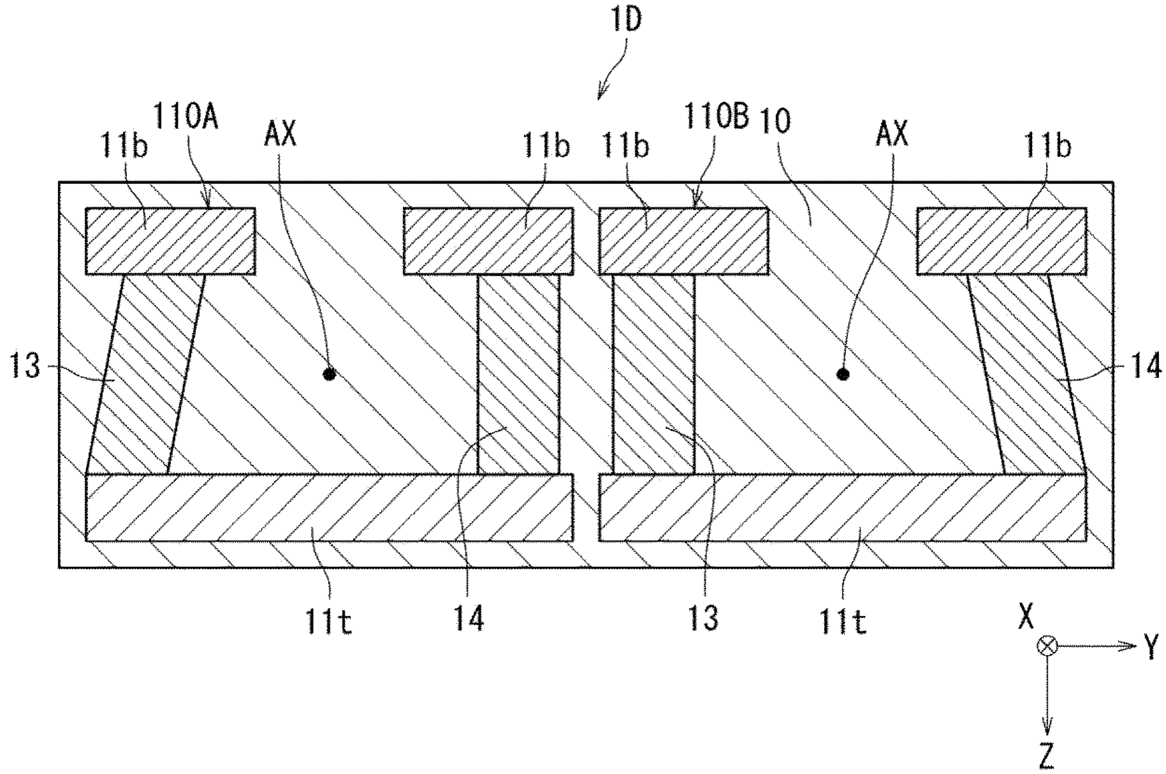
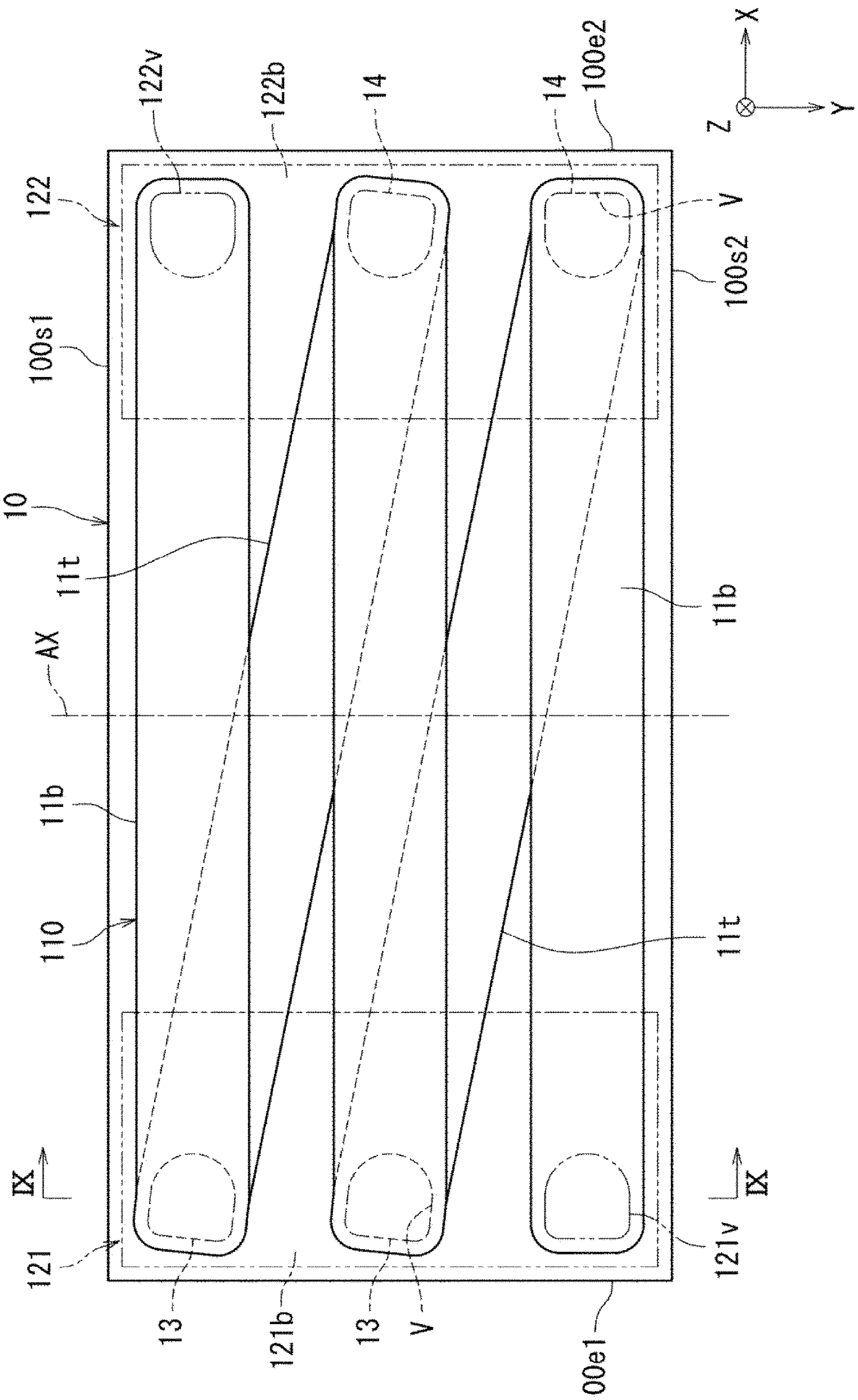
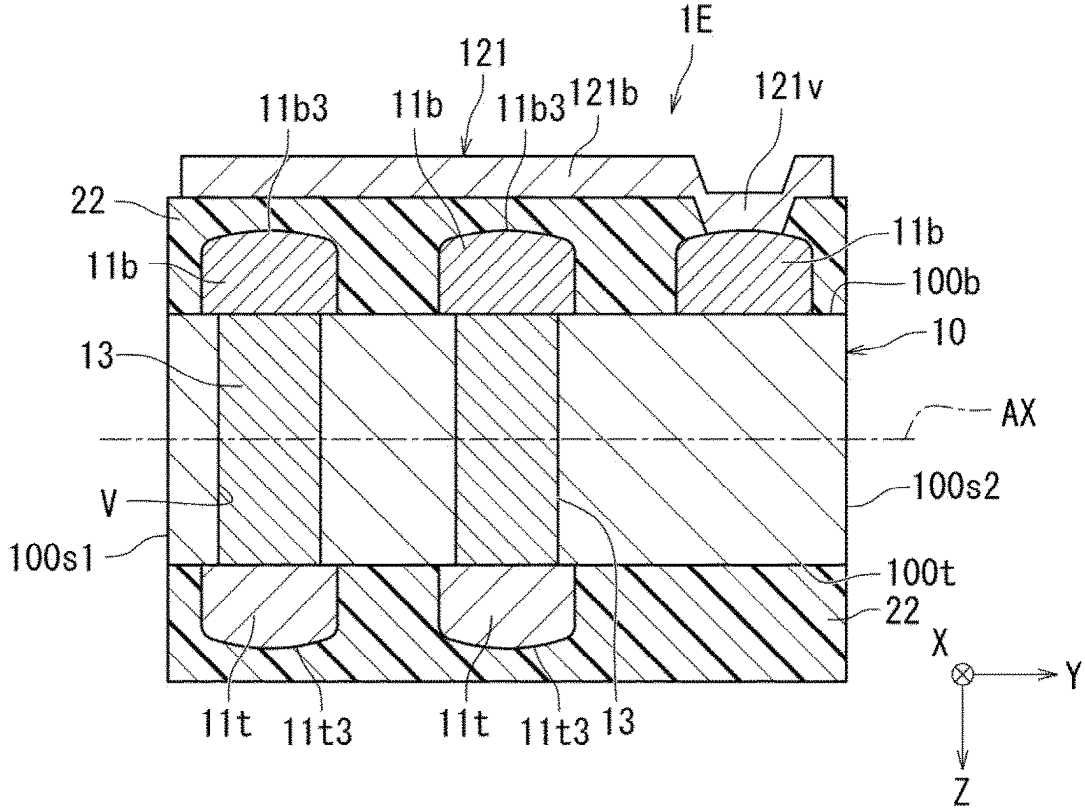


Fig. 8



122v
122b
14
14
100e2
X
Y
Z
122
V
100s2
100s1
10
11t
11b
1E
AX
11b
110
11t
IX
IX
121
121v
13
121b
13
V
100e1

Fig. 9


1E
121
121b
121v
11b3
11b
11b3
22
11b
11b
100b
10
13
AX
V
100s2
100s1
100t
22
X
Y
Z
11t
11t3
11t
11t3
13

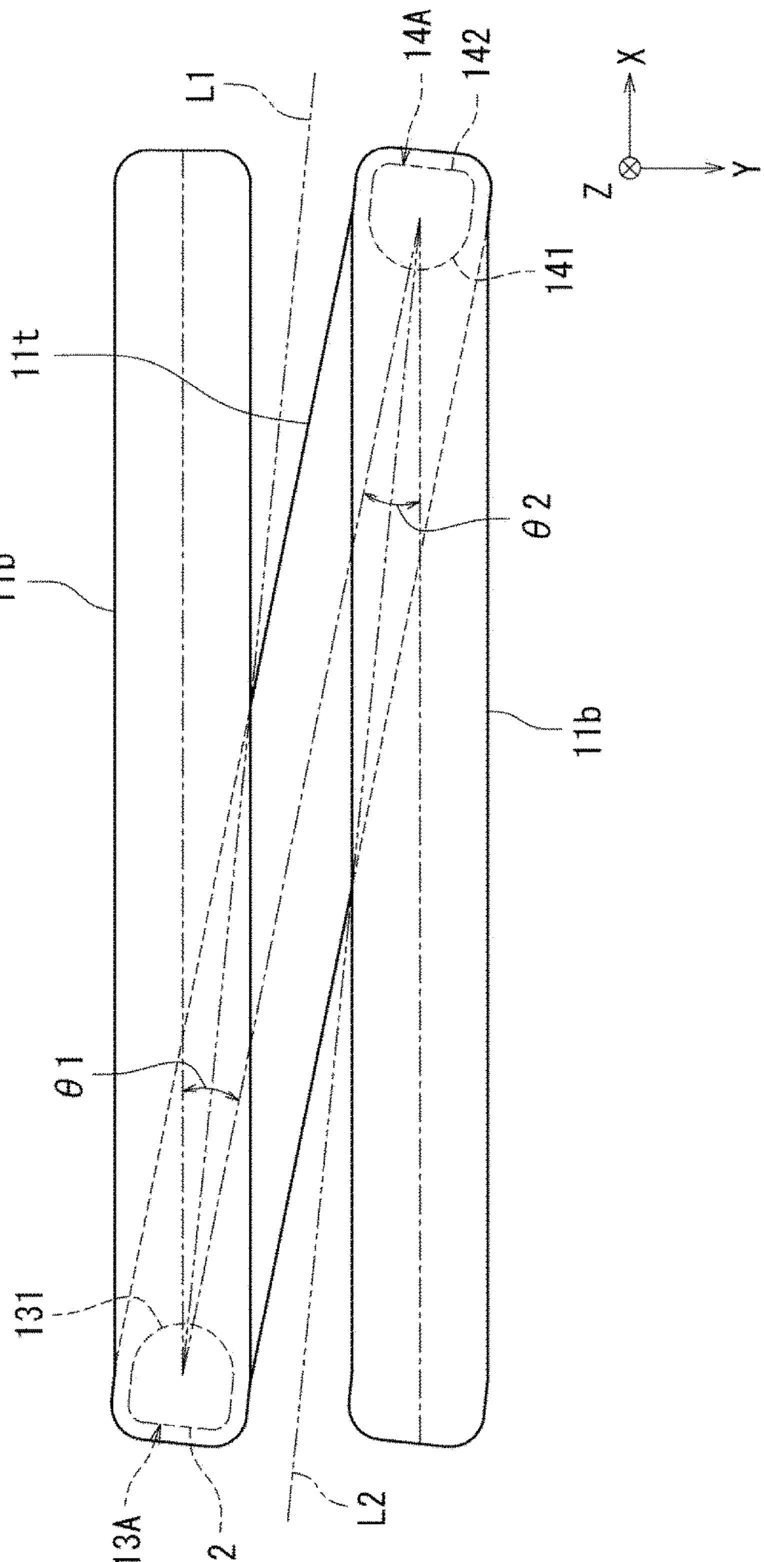


Fig. 10

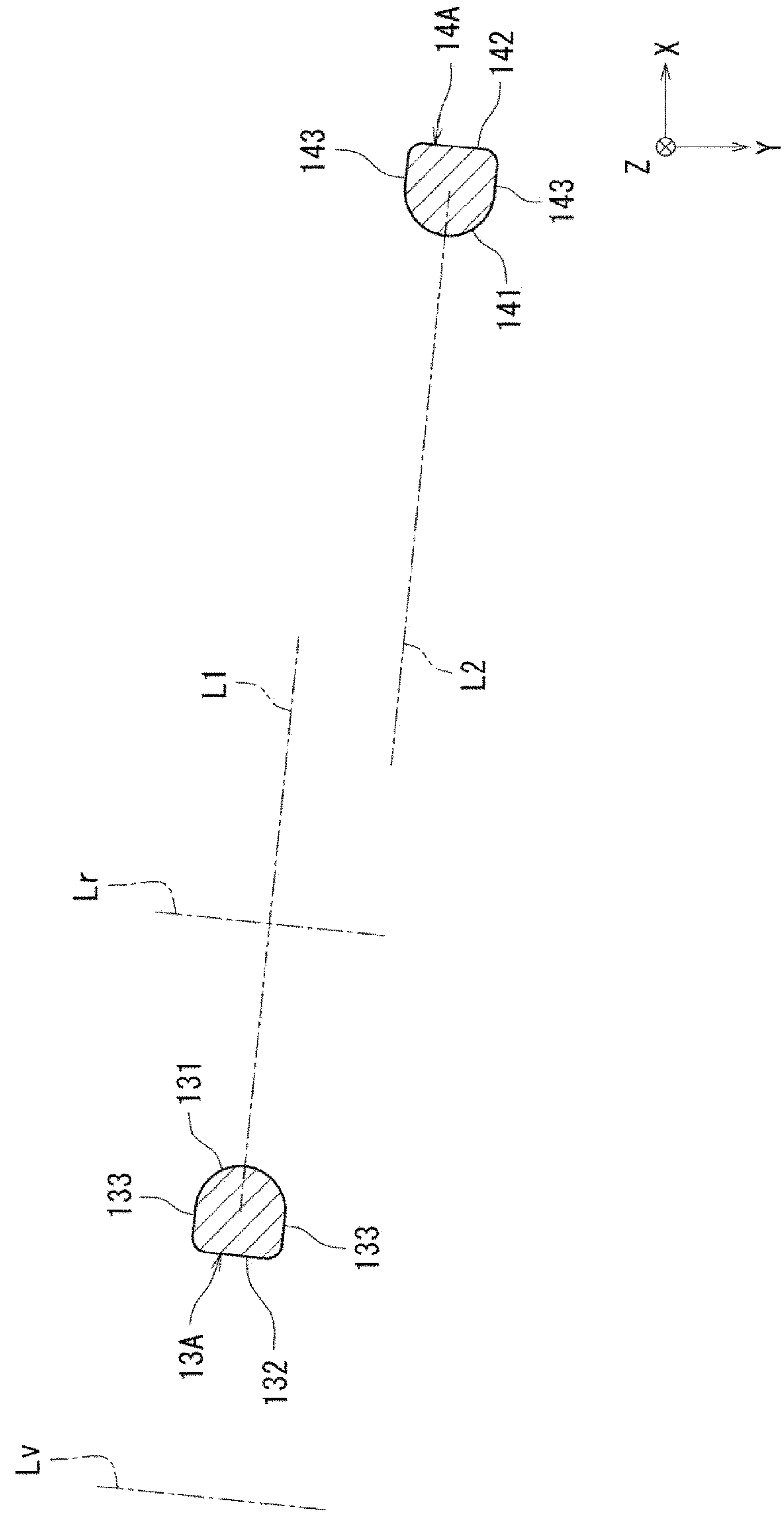


Fig. 11

Fig. 12A

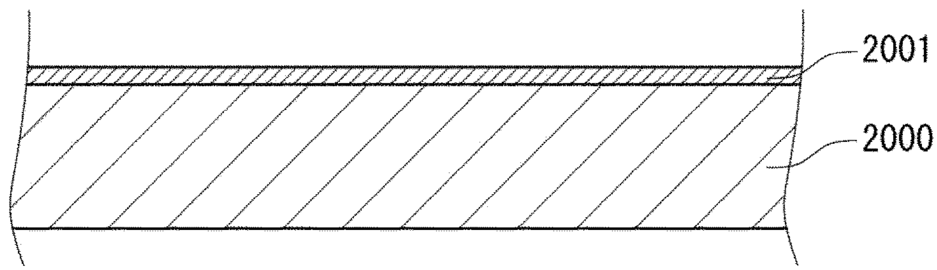


Fig. 12B

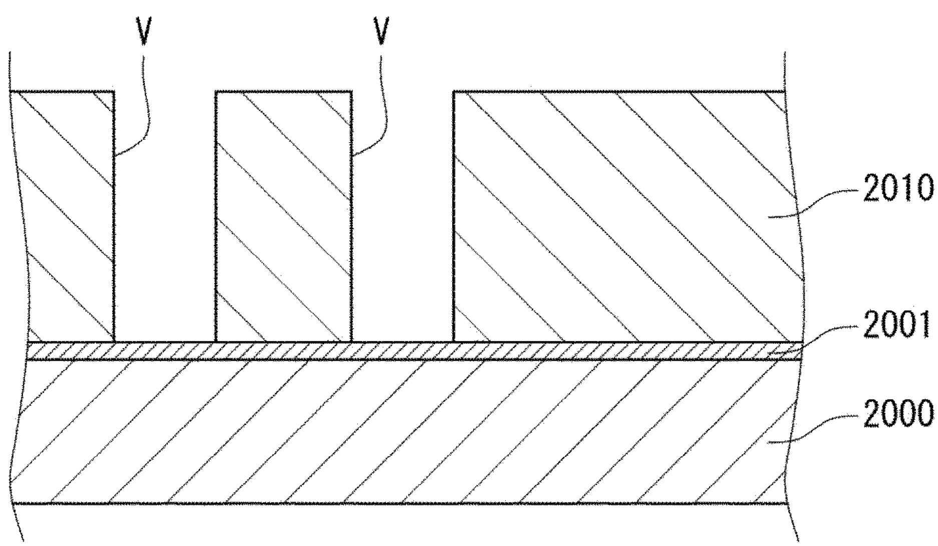


Fig. 12C

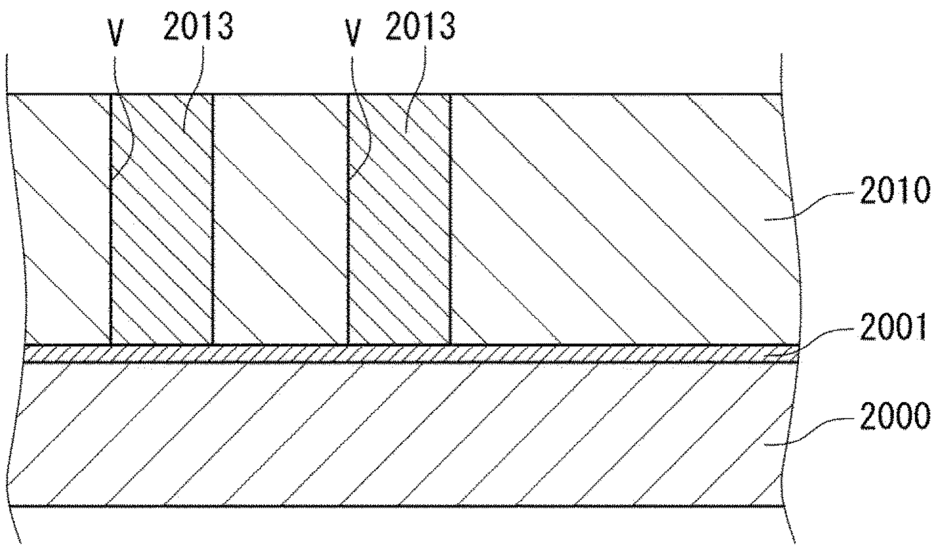


Fig. 12D

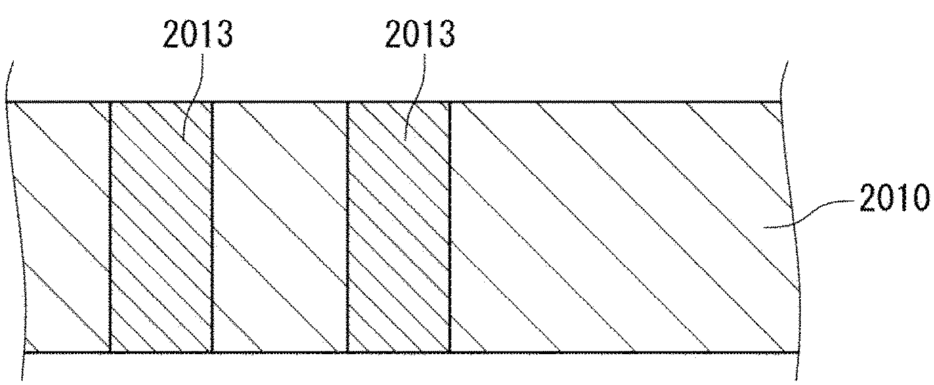


Fig. 12E

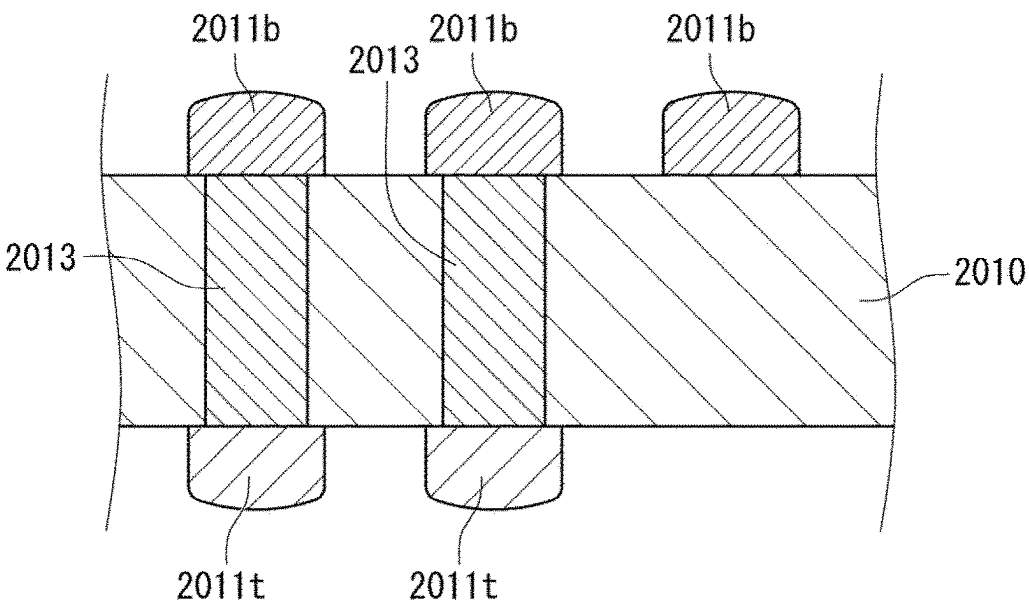


Fig. 12F

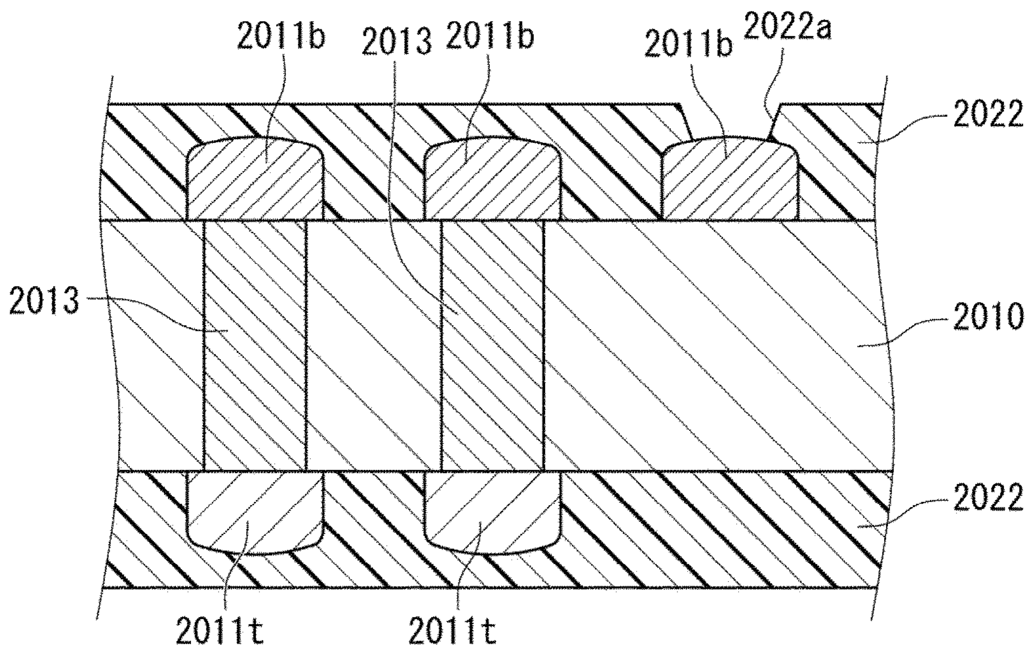


Fig. 12G

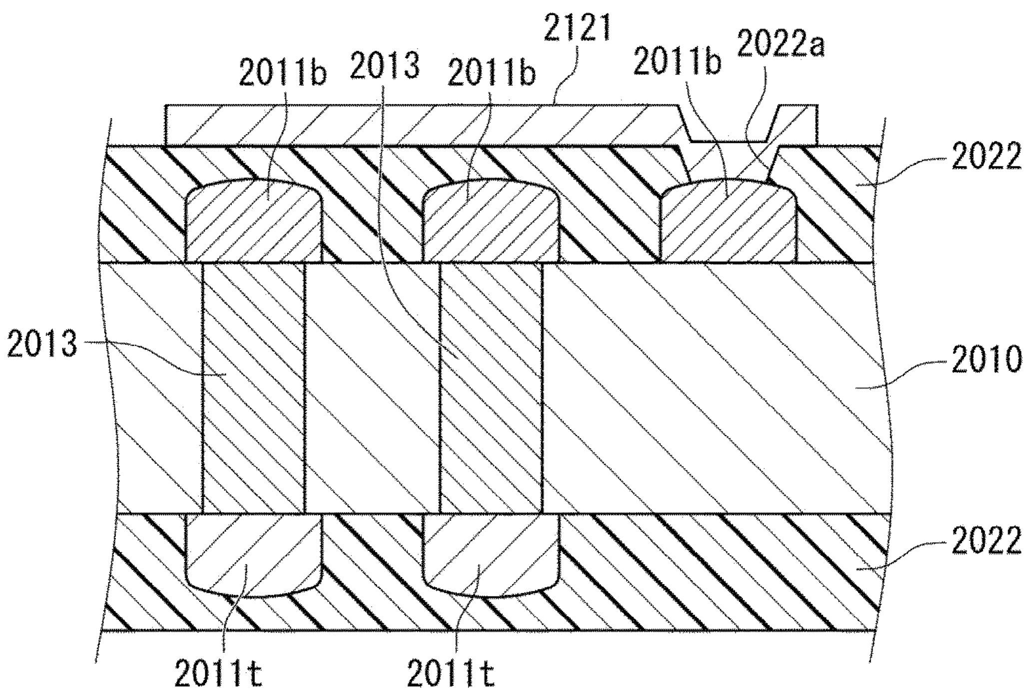


Fig. 12H

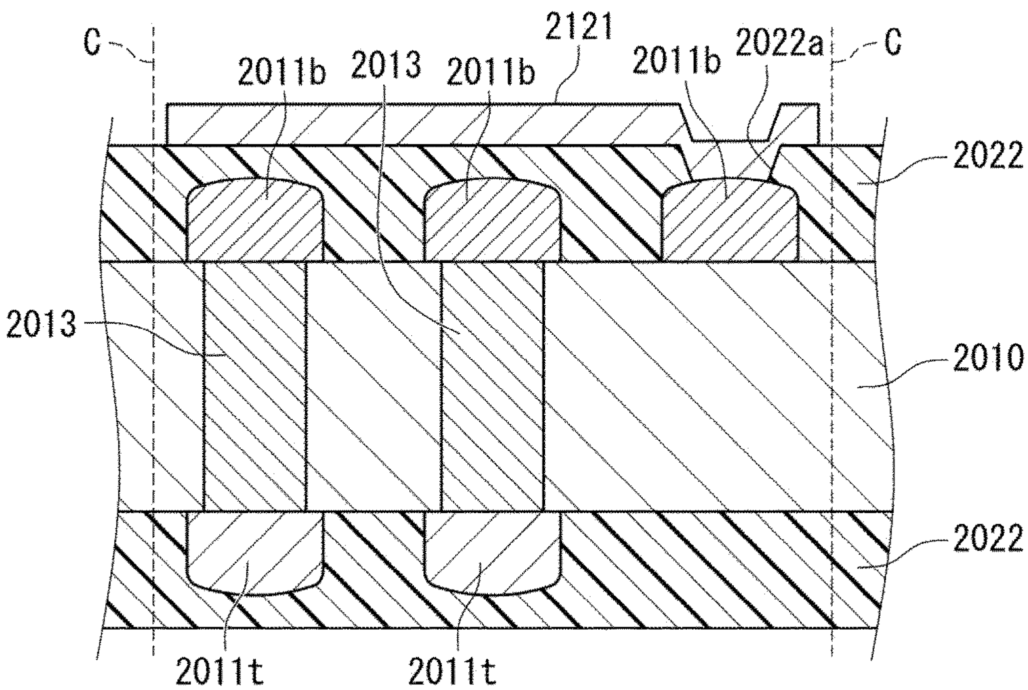


Fig. 13A

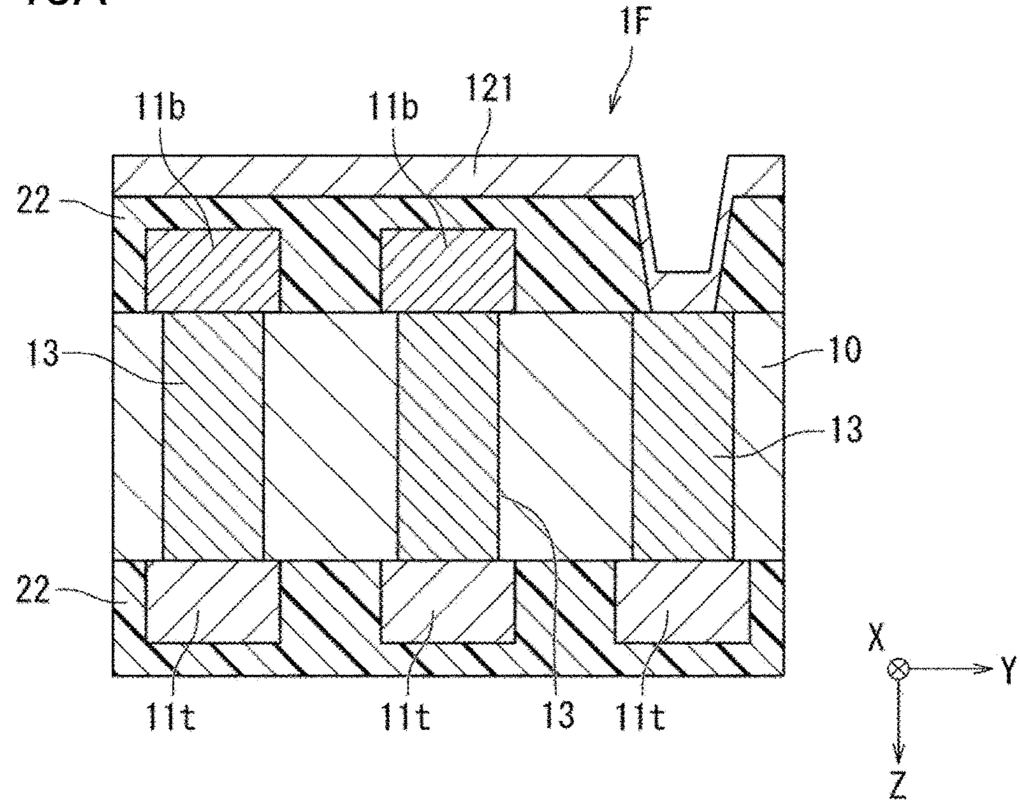


Fig. 13B

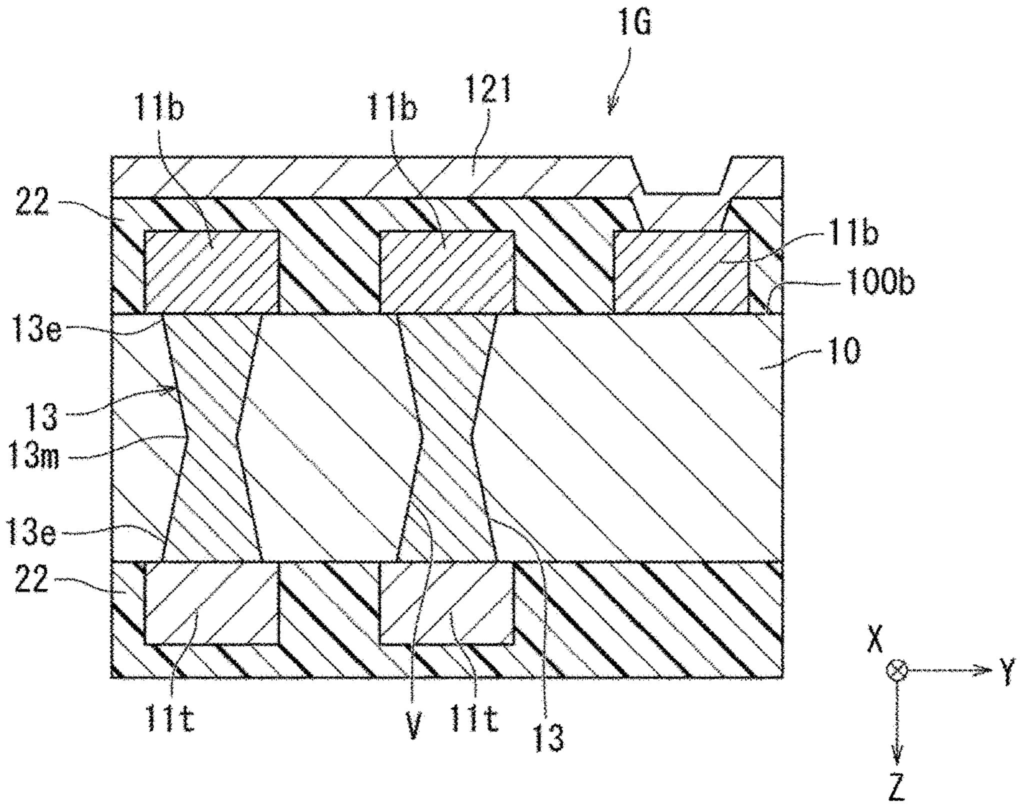


Fig. 13C

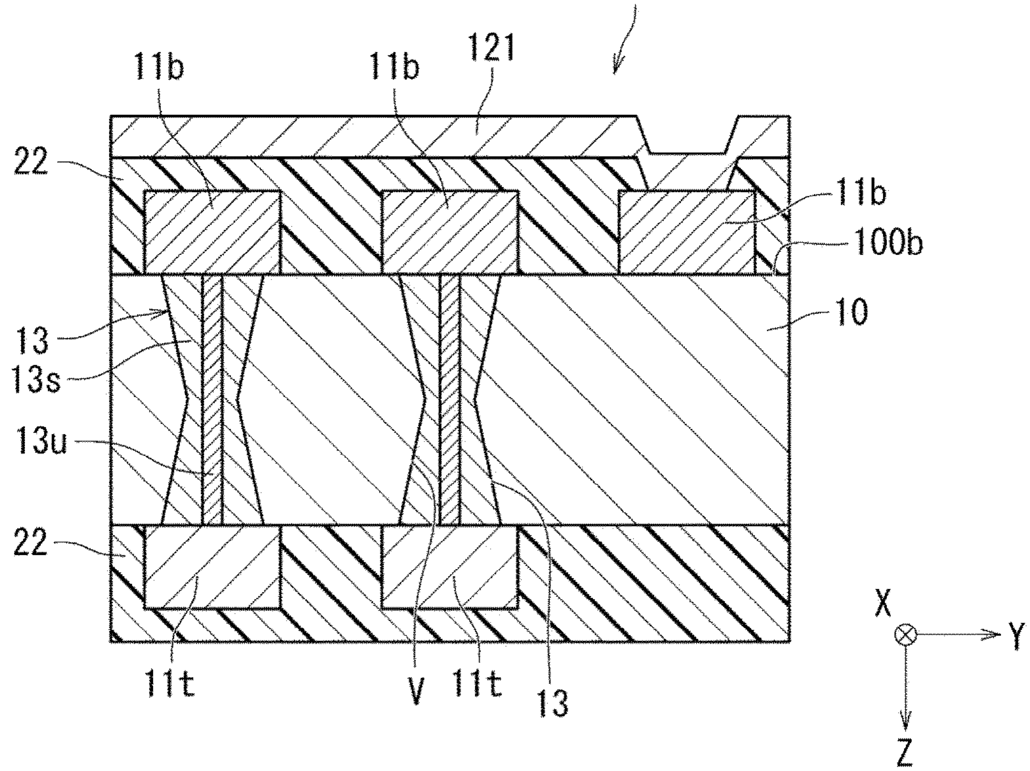


Fig. 14

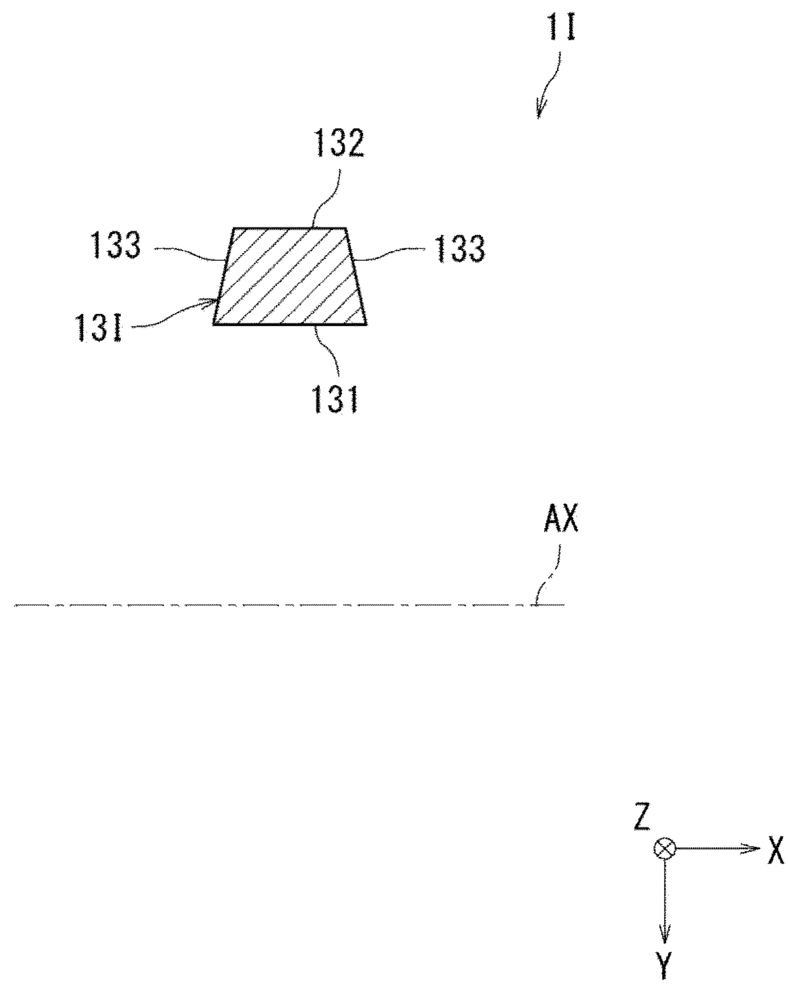
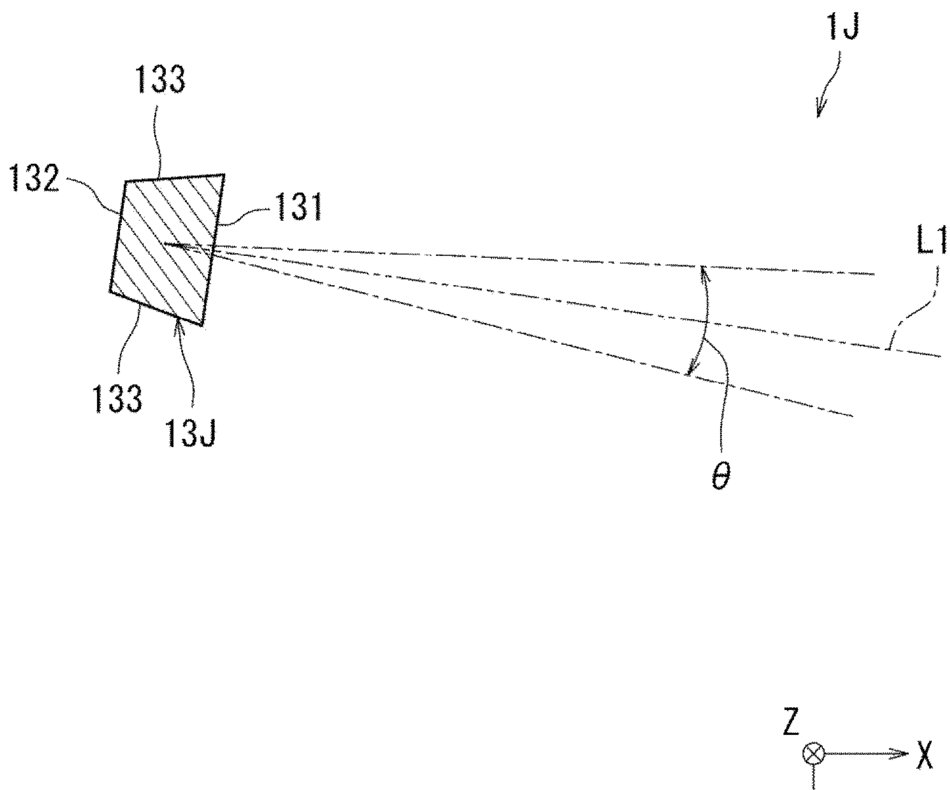


Fig. 15



INDUCTOR COMPONENT

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims benefit of priority to International Patent Application No. PCT/JP2023/030314, filed Aug. 23, 2023, and to Japanese Patent Application 2022-176448 filed Nov. 2, 2022, the entire content of each are incorporated herein by reference.

BACKGROUND

Technical Field

[0002] The present disclosure relates to an inductor component.

Background Art

[0003] Conventionally, as an inductor component, there is an inductor component described in Japanese Patent No. 6652280. The inductor component includes an element body, a coil that is provided in the element body and is wound along an axial direction, and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil.

[0004] The coil has a plurality of coil patterns layered along an axis. The coil patterns adjacent to each other in the axial direction are connected via a conductive via. Each coil pattern includes a wiring portion extending in a direction orthogonal to the axis and a pad portion that is provided at an end portion of the wiring portion and is connected to the conductive via. A width of the pad portion is wider than a width of the wiring portion in order to improve the connectivity between the pad portion and the conductive via.

SUMMARY

[0005] Incidentally, in the conventional inductor component, since the width of the pad portion is wider than the width of the wiring portion, a part of the pad portion is positioned on an inner side in a radial direction of the coil with respect to the wiring portion. Therefore, an inner diameter of the coil becomes small, and the efficiency of acquisition of inductance is not necessarily high.

[0006] In this regard, the present disclosure provides an inductor component capable of increasing the efficiency of acquisition of inductance.

[0007] Accordingly, one aspect of the present disclosure provides an inductor component comprising an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, on a cross section parallel to the first principal surface and including the axis, the first penetration wirings have respective inner circumferential edges facing the axis side and respective outer circumferential edges facing a side opposite to the axis, and the inner circumferential edges have a length longer than a length of the outer circumferential edges.

[0008] Here, the axis indicates an intersection line of a first plane passing through centers between the first coil wirings and the second coil wirings and a second plane passing through centers between the first penetration wirings and the second penetration wirings. The inner circumferential edges facing the axis side indicate regions on entire circumferential edges of the first penetration wirings which are projected on the axis, when the first penetration wirings are projected toward the axis in a direction orthogonal to the axis. The outer circumferential edges facing the side opposite to the axis indicate regions on the entire circumferential edges of the first penetration wirings that are projected on a virtual line, when the virtual line is defined to be parallel to the axis on the side opposite to the axis with respect to the first penetration wirings, and the first penetration wirings are projected toward the virtual line in a direction orthogonal to the axis. Regions on the entire circumferential edges of the first penetration wirings which are parallel to the direction orthogonal to the axis do not correspond to the inner circumferential edges and the outer circumferential edges. That "the external electrode is provided on the element body" specifically indicates that the external electrode is provided on an outer surface side of the element body. For example, this includes a case where the external electrode is provided immediately on an outer surface of the element body, a case where the external electrode is provided on an outer side of the element body via an additional member on the element body, and a case where the external electrode is provided on the outer surface of the external electrode in a state where a part of the external electrode is embedded in the element body.

[0009] According to the embodiment, since the coil includes the first coil wirings, the first penetration wirings, the second coil wirings, and the second penetration wirings, and each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order, it is possible to increase an inner diameter of the coil such that it is possible to increase the efficiency of acquisition of inductance. In addition, a Q value can be increased by increasing the efficiency of acquisition of inductance. Further, since the length of the inner circumferential edges of the first penetration wirings is longer than the length of the outer circumferential edges of the first penetration wirings, it is possible to increase a surface area of an inner surface of the coil such that an electrical resistance value at a high frequency is decreased, and a Q value at the high frequency is improved.

[0010] Another aspect of the present disclosure provides an inductor component comprising an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, when a bisector of an angle formed by each of the first coil wirings and each of the second coil wirings connected to a reference first penetration wiring that is one of the first penetration wirings is defined when viewed in a direction orthogonal to the first principal surface, on a cross section parallel to the first principal surface and including the axis, the reference first penetration wiring has an inner circumferential edge facing the bisector side and an outer circumferential edge facing a side opposite to the bisector, and the inner circumferential edge has a length longer than a length of the outer circumferential edge.

[0011] Here, the angle formed by each of the first coil wirings and each of the second coil wirings is an angle between a center line of a width of each of the first coil wirings and a center line of a width of each of the second coil wirings when viewed in the direction orthogonal to the first principal surface. The inner circumferential edge facing the bisector side indicates a region on an entire circumferential edge of the reference first penetration wiring which is projected on an orthogonal line, when the reference first penetration wiring is projected toward the orthogonal line orthogonal to the bisector in a direction parallel to the bisector. The outer circumferential edge facing the side opposite to the bisector indicates a region on the entire circumferential edge of the reference first penetration wiring that is projected on a virtual line, when the virtual line is defined to be parallel to the orthogonal line on a side opposite to the orthogonal line with respect to the reference first penetration wiring, and the reference first penetration wiring is projected toward the virtual line in a direction parallel to the bisector. A region on the entire circumferential edge of the reference first penetration wiring on which a direction orthogonal to the circumferential edge is opposite to a direction parallel to the bisector does not correspond to the inner circumferential edge and the outer circumferential edge.

[0012] According to the embodiment, since the coil includes the first coil wirings, the first penetration wirings, the second coil wirings, and the second penetration wirings, and each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order, it is possible to increase an inner diameter of the coil such that it is possible to increase the efficiency of acquisition of inductance. In addition, a Q value can be increased by increasing the efficiency of acquisition of inductance. Further, since the length of the inner circumferential edges of the reference first penetration wirings is longer than the length of the outer circumferential edges of the reference first penetration wirings, it is possible to increase a surface area of an inner surface of the coil such that the electrical resistance value at the high frequency is decreased, and the Q value at the high frequency is improved.

[0013] Still another aspect of the present disclosure provides an inductor component comprising an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, on a cross section parallel to the first principal surface and including the axis, the first penetration wirings have respective inner circumferential edges parallel to the axis and facing the axis side and respective outer circumferential edges parallel to the axis and facing a side opposite to the axis, and the inner circumferential edges have a length longer than a length of the outer circumferential edge.

[0014] According to the embodiment, since the coil includes the first coil wirings, the first penetration wirings, the second coil wirings, and the second penetration wirings, and each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order, it is possible to increase an inner diameter of the coil such that it is possible to increase the efficiency of acquisition of inductance. In addition, a Q value can be increased by increasing the efficiency of acquisition of inductance. Further, since the length of the inner circumferential edges of the first penetration wirings is longer than the length of the outer circumferential edges of the first penetration wirings, it is possible to increase the surface area of the inner surface of the coil such that the electrical resistance value at the high frequency is decreased, and the Q value at the high frequency is improved.

[0015] Still another aspect of the present disclosure provides an inductor component comprising an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, when a bisector of an angle formed by each of the first coil wirings and each of the second coil wirings connected to a reference first penetration wiring that is one of the first penetration wirings is defined when viewed in a direction orthogonal to the first principal surface, on a cross section parallel to the first principal surface and including the axis, the reference first penetration wiring has an inner circumferential edge parallel to a direction orthogonal to the bisector and facing the bisector side and an outer circumferential edge parallel to the direction orthogonal to the bisector and facing a side opposite to the bisector, and the inner circumferential edge has a length longer than a length of the outer circumferential edge.

[0016] Here, the angle formed by each of the first coil wirings and each of the second coil wirings is the angle between the center line of the width of each of the first coil wirings and the center line of the width of each of the second coil wirings when viewed in the direction orthogonal to the first principal surface.

[0017] According to the embodiment, since the coil includes the first coil wirings, the first penetration wirings, the second coil wirings, and the second penetration wirings, and each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order, it is possible to increase an inner diameter of the coil such that it is possible to increase the efficiency of acquisition of inductance. In addition, a Q value can be increased by increasing the efficiency of acquisition of inductance. Further, since the length of the inner circumferential edges of the reference first penetration wirings is longer than the length of the outer circumferential edges of the reference first penetration wirings, it is possible to increase the surface area of the inner surface of the coil such that the electrical resistance value at the high frequency is decreased, and the Q value at the high frequency is improved.

[0018] Preferably, in the embodiment of the inductor component, the element body contains SiO_2.

[0019] According to the embodiment, it is possible to impart insulation properties and stiffness to the element body.

[0020] Preferably, in an embodiment of the inductor component, the inner circumferential edges of the first penetration wirings have respective convex curved portions.

[0021] According to the embodiment, it is possible to distribute stress applied to the curved portions of the inner circumferential edges of the first penetration wirings.

[0022] Preferably, in the embodiment of the inductor component, the plurality of first penetration wirings include two of the first penetration wirings in which orientations of the curved portions of the inner circumferential edges are different from each other.

[0023] Here, an orientation of the curved portions indicates a direction in which a midpoint of each curved portion and a center line of each first penetration wiring are connected.

[0024] According to the embodiment, it is possible to change the orientation of the curved portions of the first penetration wirings depending on arrangement of the first coil wirings and the second coil wirings.

[0025] Preferably, in the embodiment of the inductor component, the inner circumferential edges of the first penetration wirings have a length which is 1.5 times or more a length of the outer circumferential edges of the first penetration wirings.

[0026] According to the embodiment, it is possible to increase the length of the inner circumferential edges of the first penetration wirings, and it is possible to further decrease an electrical resistance value at a high frequency.

[0027] Preferably, in the embodiment of the inductor component, when viewed in the direction orthogonal to the first principal surface, a first end portion of each of the first coil wirings is connected to a first end portion of each of the first penetration wirings, and an outer shape of the coil of the first end portion of each of the first coil wirings conforms to an outer shape of the coil of the first end portion of each of the first penetration wirings.

[0028] According to the embodiment, the shape of the first end portion of each of the first coil wirings can be made to correspond to the shape of the first end portion of each of the first penetration wirings, and it is possible to decrease the DC electrical resistance of a connection part between each of the first coil wirings and each of the first penetration wirings.

[0029] Preferably, in the embodiment of the inductor component, when viewed in the direction orthogonal to the first principal surface, an angle formed by each of the first coil wirings and each of the second coil wirings connected to the same first penetration wiring is 5° or larger and 45° or smaller (i.e., from 5° to) 45°.

[0030] According to the embodiment, since the coils are densely wound, it is possible to improve the inductance.

[0031] Preferably, in the embodiment of the inductor component, on a cross section orthogonal to an extending direction of the first coil wirings, upper surfaces of the first coil wirings positioned on a side opposite to the axis have a convex shape protruding upward on a side opposite to the axis.

[0032] According to the embodiment, it is possible to increase a distance between the upper surfaces of two first coil wirings adjacent to each other in the axial direction, and it is possible to decrease parasitic capacitance between the adjacent first coil wirings such that it is possible to increase the self-resonant frequency of the inductor component.

[0033] Preferably, in the embodiment of the inductor component, the first external electrode is disposed on the first coil wirings, and the upper surfaces of the first coil wirings face the first external electrode.

[0034] According to the embodiment, it is possible to increase a distance between upper surfaces of the first external electrode and each of the first coil wirings, and it is possible to decrease parasitic capacitance between the first external electrode and each of the first coil wirings such that it is possible to increase the self-resonant frequency of the inductor component.

[0035] Preferably, in the embodiment of the inductor component, when viewed in a direction parallel to the axis, the first penetration wirings and the second penetration wirings are not parallel to each other.

[0036] According to the embodiment, it is possible to increase a distance between each of the first penetration wirings and each of the second penetration wirings, and it is possible to increase the inner diameter of the coil such that it is possible to improve the Q value.

[0037] Preferably, in the embodiment of the inductor component, the element body contains SiO_2, and the first penetration wirings contain SiO_2.

[0038] According to the embodiment, the first penetration wirings can have a linear expansion coefficient equal to a linear expansion coefficient of the element body, and it is possible to reduce cracks between the first penetration wirings and the element body.

[0039] Preferably, in the embodiment of the inductor component, each of the first penetration wirings has a void portion or a resin portion.

[0040] According to the embodiment, stress due to a difference in linear expansion coefficient between the first penetration wirings and the element body can be absorbed by the void portion or the resin portion, and this enables the stress to be alleviated.

[0041] Preferably, in the embodiment of the inductor component, each of the first penetration wirings includes a conductive layer positioned on an outer circumferential side when viewed in an extending direction of the first penetration wirings, and a non-conductive layer positioned inside the conductive layer.

[0042] According to the embodiment, since a current mainly flows in a surface of the first penetration wirings due to a skin effect in the case of use in a high frequency band, the Q value is not decreased by providing the conductive layer on the outer circumferential side. In addition, by providing the non-conductive layer inside, stress can be alleviated, and manufacturing costs can be reduced by using no conductor.

[0043] Preferably, in the embodiment of the inductor component, a length of the coil in an axial direction is shorter than an inner diameter of the coil.

[0044] According to the embodiment, since the coil length is short and the inner diameter of the coil is large, it is possible to improve the Q value.

[0045] Preferably, in the embodiment of the inductor component, the first penetration wirings extend in the direction orthogonal to the first principal surface, and a cross-sectional area of at least one of both end portions of each of the first penetration wirings in the extending direction is larger than a cross-sectional area of a central portion of each of the first penetration wirings in the extending direction.

[0046] According to the embodiment, it is possible to increase the cross-sectional area of the end portion of the first penetration wiring such that connectivity between the first penetration wiring and at least one of the first coil wiring and the second coil wiring can be improved. In addition, when a hole portion is formed in the element body, the hole portion is filled with a conductive material by fill plating or the like, and the first penetration wiring is formed in the hole portion of the element body, it is easy to fill the hole portion on an opening side with the conductive material. Since the cross-sectional area of the end portion of the first penetration wiring is large, and the cross-sectional area of the central portion of the first penetration wiring is small, the first penetration wiring is easily formed.

[0047] Preferably, in the embodiment of the inductor component, when viewed in the direction orthogonal to the first principal surface, the first external electrode and the second external electrode are positioned on an inner side with respect to an outer surface of the element body.

[0048] According to the configuration, since the first external electrode and the second external electrode are not in contact with the outer surfaces of the element body, loads applied to the first external electrode and the second external electrode can be decreased, and deformation and peeling of the first external electrode and the second external electrode can be reduced, when division into individual inductor components is performed. Therefore, even if the inductor component has a small size, it is possible to prevent the first external electrode and the second external electrode from being deformed or peeled off.

[0049] Preferably, the embodiment of the inductor component further comprises an organic insulating body provided on the first principal surface. The element body is an inorganic insulating body, and the organic insulating body is positioned on an inner side with respect to an outer surface of the inorganic insulating body when viewed in the direction orthogonal to the first principal surface.

[0050] According to the embodiment, since the organic insulating body is provided, the organic insulating body easily imparts flowability, the organic insulating body easily fills a space between the first coil wirings adjacent to each other and enables insulating properties to be improved, in a case where the first coil wirings are covered with the organic insulating body. In addition, since the organic insulating body is not in contact with the outer surface of the inorganic insulating body, it is possible to decrease a load applied to the organic insulating body and reduce deformation and peeling of the organic insulating body when division into individual inductor components is performed.

[0051] According to the inductor component which is the one aspect of the present disclosure, it is possible to increase the efficiency of acquisition of inductance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052] FIG. **1** is a schematic perspective view of an inductor component from a bottom surface side according to a first embodiment.

[0053] FIG. **2** is a cross-sectional view taken along line II-II in FIG. **1**.

[0054] FIG. **3** is a cross-sectional view taken along line III-III in FIG. **1**.

[0055] FIG. **4** is an XY cross-sectional view of a first penetration wiring and a second penetration wiring.

[0056] FIG. **5** is an enlarged view of a part of FIG. **1**.

[0057] FIG. **6**A is a schematic cross-sectional view illustrating a method for manufacturing an inductor component.

[0058] FIG. **6**B is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0059] FIG. **6**C is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0060] FIG. **6**D is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0061] FIG. **6**E is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0062] FIG. **6**F is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0063] FIG. **6**G is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0064] FIG. **6**H is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0065] FIG. **6**I is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0066] FIG. **6**J is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0067] FIG. **6**K is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0068] FIG. **6**L is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0069] FIG. **6**M is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0070] FIG. **7**A is a cross-sectional view showing a first modification example of the inductor component.

[0071] FIG. **7**B is a cross-sectional view showing a second modification example of the inductor component.

[0072] FIG. **7**C is a cross-sectional view showing a third modification example of the inductor component.

[0073] FIG. **7**D is a cross-sectional view showing a fourth modification example of the inductor component.

[0074] FIG. **8** is a schematic bottom view of an inductor component from a bottom surface side according to a second embodiment.

[0075] FIG. **9** is a cross-sectional view taken along line IX-IX in FIG. **8**.

[0076] FIG. **10** is a schematic bottom view of a coil from the bottom surface side.

[0077] FIG. **11** is an XY cross-sectional view of a first penetration wiring and a second penetration wiring.

[0078] FIG. **12**A is a schematic cross-sectional view illustrating a method for manufacturing an inductor component.

[0079] FIG. **12**B is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0080] FIG. **12**C is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0081] FIG. **12**D is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0082] FIG. **12**E is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0083] FIG. **12**F is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0084] FIG. **12**G is a schematic cross-sectional view illustrating the method for manufacturing an inductor component.

[0085] FIG. **12**H is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0086] FIG. **13**A is a cross-sectional view showing a first modification example of the inductor component;

[0087] FIG. **13**B is a cross-sectional view showing a second modification example of the inductor component;

[0088] FIG. **13**C is a cross-sectional view showing a third modification example of the inductor component;

[0089] FIG. **14** is an XY cross-sectional view showing a first penetration wiring of an inductor component according to a third embodiment; and

[0090] FIG. **15** is an XY cross-sectional view showing a first penetration wiring of an inductor component according to a fourth embodiment.

DETAILED DESCRIPTION

[0091] Hereinafter, an inductor component which is the one aspect of the present disclosure will be described in detail with reference to embodiments shown in the drawings. Note that the drawings include some schematic drawings, and may not reflect actual dimensions and ratios.

First Embodiment

[0092] An inductor component **1** according to the first embodiment will be described below. FIG. **1** shows a schematic bottom view of the inductor component **1** from a bottom surface side thereof. FIG. **2** is a cross-sectional view taken along line II-II in FIG. **1**. FIG. **3** is a cross-sectional view taken along line III-III in FIG. **1**. Note that, in FIG. **1**, an external electrode is drawn by a two-dot chain line for convenience. In addition, in FIG. **1**, an element body **10** is drawn transparently so that a structure thereof can be easily understood, but may be translucent or opaque.

1. General Configuration

[0093] A general configuration of the inductor component **1** will be described. The inductor component **1** is, for example, a surface mount inductor component that is used in a high-frequency signal transmission circuit. As shown in FIGS. **1**, **2**, and **3**, the inductor component **1** includes the element body **10**, a coil **110** that is provided in the element body **10** and is wound in a spiral shape along an axis AX, and a first external electrode **121** and a second external electrode **122** that are provided on the element body **10** and are electrically connected to the coil **110**.

[0094] The element body **10** has a length, a width, and a height. The element body **10** has a first end surface **100*e*1** and a second end surface **100*e*2** on both end sides in a length direction, a first side surface **100*s*1** and a second side surface **100*s*2** on both end sides in a width direction, and a bottom surface **100*b*** and a top surface **100*t*** on both end sides in a height direction. That is, outer surfaces **100** of the element body **10** include the first end surface **100*e*1** and the second end surface **100*e*2**, the first side surface **100*s*1** and the second side surface **100*s*2**, and the bottom surface **100*b*** and the top surface **100*t***. The bottom surface **100*b*** corresponds to an example of a "first principal surface" described in CLAIMS, and the top surface **100*t*** corresponds to an example of a "second principal surface" described in CLAIMS.

[0095] As shown in the drawings, hereinafter, for convenience of description, a direction that is the length direction (longitudinal direction) of the element body **10** and is from the first end surface **100*e*1** toward the second end surface **100*e*2** is referred to as an X direction. In addition, a direction that is the width direction of the element body **10** and is from the first side surface **100*s*1** toward the second side surface **100*s*2** is referred to as a Y direction. In addition, a direction that is the height direction of the element body **10** and is from the bottom surface **100*b*** toward the top surface **100*t*** is referred to as a Z direction. The X direction, the Y direction, and the Z direction are directions orthogonal to each other and form a right-handed system when arranged in an order of X, Y, and Z.

[0096] In this specification, the "outer surfaces **100** of the element body" including the first end surface **100*e*1**, the second end surface **100*e*2**, the first side surface **100*s*1**, the second side surface **100*s*2**, the bottom surface **100*b***, and the top surface **100*t*** of the element body **10** do not simply mean surfaces of the element body **10** toward the outer circumferential sides of the element body **10**, but are surfaces serving as a boundary between an outside and an inside of the element body **10**. In addition, "above the outer surfaces **100** of the element body **10**" does not indicate an absolute direction such as a vertical upward direction defined in the direction of gravity, but indicates a direction toward the outside with the outer surfaces **100** as a reference, of the outside and inside with the outer surfaces **100** as the boundary therebetween. Hence, "above the outer surfaces **100**" indicates a relative direction determined depending on an orientation of the outer surfaces **100**. In addition, "above" with respect to a certain element means not only above from the corresponding element, that is, an upper position via another object on the corresponding element or an upper position apart from the corresponding element at an interval, but also a position immediately on the corresponding element to be in contact with the corresponding element.

[0097] The axis AX of the coil **110** is disposed parallel to the bottom surface **100*b***. The coil **110** includes a plurality of bottom surface wirings **11*b*** which are provided on the bottom surface **100*b*** side with respect to the axis AX and are arranged along the axis AX on a plane parallel to the bottom surface **100*b***, a plurality of top surface wirings **11*t*** which are provided on the top surface **100*t*** side with respect to the axis AX and are arranged along the axis AX on a plane parallel to the top surface **100*t***, a plurality of first penetration wirings **13** which extend from the respective bottom surface wirings **11*b*** toward the respective top surface wirings **11*t***, and are arranged along the axis AX, and a plurality of second penetration wirings **14** which extend from the respective bottom surface wirings **11*b*** toward the respective top surface wirings **11*t***, are provided on a side opposite to the respective first penetration wirings **13** with respect to the axis AX, and are arranged along the axis AX. Each of the bottom surface wirings **11*b***, each of the first penetration wirings **13**, each of the top surface wirings **11*t***, and each of the second penetration wirings **14** form at least a part of a spiral shape by being connected in this order.

[0098] The bottom surface wiring **11*b*** corresponds to an example of a "first coil wiring" described in CLAIMS, and the top surface wiring **11*t*** corresponds to an example of a "second coil wiring" described in CLAIMS. The axis AX indicates an intersection line of a first plane passing through centers between the bottom surface wirings **11*b*** and the top surface wirings **11*t*** and a second plane passing through centers between the first penetration wirings **13** and the second penetration wirings **14**. That is, the axis AX is a straight line passing through a center of an inner diameter portion of the coil **110**. The axis AX of the coil **110** does not have a dimension in a direction orthogonal to the axis AX.

[0099] According to the configuration described above, since the coil **110** includes the bottom surface wirings **11*b***, the first penetration wirings **13**, the top surface wirings **11*t***, and the second penetration wirings **14**, and each of the bottom surface wirings **11*b***, each of the first penetration wirings **13**, each of the top surface wirings **11*t***, and each of the second penetration wirings **14** form at least a part of the spiral shape by being connected in this order, it is possible to increase an inner diameter of the coil **110** such that it is possible to increase the efficiency of acquisition of inductance. In addition, a Q value can be increased by increasing the efficiency of acquisition of inductance.

[0100] To be more specific, since pad portions of a conventional inductor component or the bottom surface wirings **11*b*** and the top surface wirings **11*t*** of the present embodiment are "reception portions" of wirings (conductive vias of the conventional inductor component or the first penetration wirings **13** and the second penetration wirings **14** of the present embodiment) which penetrate an element body, the pad portions and the bottom and top surface wirings have a shape expanding perpendicularly to a direction in which to penetrate the element body. Here, in a configuration of the conventional inductor component, since the conductive vias extend in a direction parallel to an axis of a coil, the pad portions are expanded in a direction perpendicular to the axis of the coil and are likely to have a structure in which magnetic flux generated in an axial direction of the coil is blocked.

[0101] On the other hand, in the present embodiment, since the first penetration wiring **13** and the second penetration wiring **14** extend in a direction perpendicular to the axis AX of the coil **110**, the bottom surface wiring **11*b*** and the top surface wiring **11*t*** are expanded in a direction parallel to the axis AX of the coil **110**. Accordingly, it is difficult for the bottom surface wiring **11*b*** and the top surface wiring **11*t*** to have a structure in which magnetic flux generated in an axis AX direction is blocked. That is, according to the present embodiment, it is possible to have the structure in which it is difficult to block the magnetic flux such that it is possible to improve the efficiency of acquisition of inductance and the Q value.

[0102] FIG. **4** is an XY cross-sectional view of the first penetration wiring **13** and the second penetration wiring **14**. As shown in FIG. **4**, on a cross section parallel to the bottom surface **100***b* and including the axis AX, the first penetration wiring **13** has an inner circumferential edge **131** facing the axis AX side, an outer circumferential edge **132** facing a side opposite to the axis AX, and a side edge **133** parallel to a direction orthogonal to the axis AX. A length of the inner circumferential edge **131** is longer than a length of the outer circumferential edge **132**. In FIG. **4**, for convenience, the inner circumferential edge **131** is represented by a dotted line, the outer circumferential edge **132** is represented by a chain line, and the side edge **133** is represented by a solid line.

[0103] The inner circumferential edge **131** is a region on an entire circumferential edge of the first penetration wiring **13** which is projected on the axis AX, when the first penetration wiring **13** is projected toward the axis AX in a direction orthogonal to the axis AX. The outer circumferential edge **132** is a region on the entire circumferential edge of the first penetration wiring **13** that is projected on a virtual line BX, when the virtual line BX is defined to be parallel to the axis AX on the side opposite to the axis AX with respect to the first penetration wiring **13**, and the first penetration wiring is projected toward the virtual line BX in a direction orthogonal to the axis AX.

[0104] According to the configuration described above, since a length of the inner circumferential edge **131** is longer than a length of the outer circumferential edge **132**, it is possible to increase a surface area of an inner surface of the first penetration wiring **13**. Consequently, it is possible to increase a surface area of an inner surface of the coil **110** such that an electrical resistance value at a high frequency is decreased, and the Q value at the high frequency is improved. To be more specific, in a case where a high frequency signal passes through the coil **110**, currents concentrate in the vicinity of a surface of the coil **110** due to a skin effect. However, in the present embodiment, since the inner circumferential edge **131** of the first penetration wiring **13** on which the high frequency signal concentrates is relatively long, the electrical resistance value decreases, and the Q value at a high frequency is improved.

[0105] In addition, the second penetration wiring **14** has the same configuration as that of the first penetration wiring **13** and has the same operation and effects as those of the above-described first penetration wiring **13**. To be more specific, the second penetration wiring **14** has an inner circumferential edge **141** facing the axis AX side, an outer circumferential edge **142** facing the side opposite to the axis AX, and a side edge **143** parallel to the direction orthogonal to the axis AX. A length of the inner circumferential edge **141** is longer than a length of the outer circumferential edge **142**. Consequently, it is possible to increase a surface area of an inner surface of the second penetration wiring **14** such that it is possible to further increase the surface area of the inner surface of the coil **110** such that the electrical resistance value at a high frequency is further decreased, and the Q value at the high frequency is further improved.

[0106] Note that, in the first penetration wiring **13**, the length of the inner circumferential edge **131** may be longer than the length of the outer circumferential edge **132**, and in the second penetration wiring **14**, the length of the inner circumferential edge **141** may be shorter than or equal to the length of the outer circumferential edge **142**.

2. Configurations of Respective Units

(Inductor Component **1**)

[0107] A volume of the inductor component **1** is 0.08 mm^3 or smaller, and a size of a long side of the inductor component **1** is 0.65 mm or smaller. The size of the long side of the inductor component **1** indicates the largest value of a length, a width, and a height of the inductor component **1**, and in this embodiment, indicates the length in the X direction. According to the configuration described above, since the volume of the inductor component **1** is small and the long side of the inductor component **1** is short, a weight of the inductor component **1** is reduced. Therefore, even if the external electrodes **121** and **122** are small, necessary mounting strength can be obtained. In addition, a thickness of the inductor component **1** is preferably 0.2 mm or smaller. This enables a thin inductor component **1** to be obtained.

[0108] To be more specific, the size (length (X direction)× width (Y direction)× height (Z direction)) of the inductor component **1** is 0.6 mm×0.3 mm×0.3 mm, 0.4 mm×0.2 mm×0.2 mm, 0.25 mm×0.125 mm×0.120 mm, or the like. In addition, the width and the height may not be equal, and may be, for example, 0.4 mm×0.2 mm×0.3 mm.

(Element Body **10**)

[0109] The element body **10** contains SiO_2. This enables insulation properties and stiffness to be imparted to the element body **10**. The element body **10** is made of, for example, a glass sintered body. The glass sintered body may contain alumina, and the strength of the element body can be further increased.

[0110] The glass sintered body is formed by, for example, layering insulating layers containing a plurality of types of glass. A layering direction of the plurality of insulating layers is the Z direction. That is, the insulating layer has a layer shape having a principal surface expanding on an X-Y plane. Note that, in the element body **10**, an interface between the plurality of insulating layers may not be distinct due to firing or the like.

[0111] Note that the element body **10** may include, for example, a glass substrate. The glass substrate may be a single-layer glass substrate, and since most of the element body is made of glass, it is possible to reduce a loss such as an eddy current loss at a high frequency.

(Coil **110**)

[0112] The coil **110** includes the plurality of bottom surface wirings **11***b*, the plurality of top surface wirings **11***t*, the plurality of first penetration wirings **13**, and the plurality of second penetration wirings **14**. The bottom surface wirings **11***b*, the first penetration wirings **13**, the top surface wirings **11***t*, and the second penetration wirings **14** are connected in this order, respectively, to constitute at least a part of the coil **110** wound in the axis AX direction.

[0113] According to the configuration described above, since the coil **110** is a so-called helical coil **110**, in a cross section orthogonal to the axis AX, it is possible to reduce a region where the bottom surface wiring **11***b*, the top surface wiring **11***t*, the first penetration wiring **13**, and the second penetration wiring **14** are laid out parallel to each other in a winding direction of the coil **110**, and it is possible to reduce stray capacitance in the coil **110**.

[0114] Here, the helical shape indicates a shape in which the number of turns of the entire coil is more than one turn, and the number of turns of the coil in the cross section orthogonal to the axis is less than one turn. One or more turns indicate a state in which the wirings of the coil have, on the cross section orthogonal to the axis, parts that are adjacent to each other in a radial direction and are laid out parallel to each other in the winding direction when viewed in an axial direction, and less than one turn indicates a state in which the wirings of the coil does not have, on the cross section orthogonal to the axis, parts that are adjacent to each other in the radial direction and are laid out parallel to each other in the winding direction when viewed in the axial direction.

[0115] The bottom surface wirings **11***b* extend only in one direction. To be more specific, the bottom surface wirings **11***b* slightly tilt in the X direction and extend in the Y direction. The plurality of bottom surface wirings **11***b* are arranged parallel to each other in the X direction. Here, in a photolithography process, when deformed illumination such as annular illumination or dipole illumination is used, pattern resolution in a specific direction can be enhanced to form a finer pattern. According to the configuration described above, since the bottom surface wirings **11***b* extend only in one direction, it is possible to form the fine bottom surface wirings **11***b* and reduce the size of the inductor component **1** by using, for example, modified illumination in the photolithography process.

[0116] The top surface wirings **11***t* extend only in one direction. To be more specific, the top surface wirings **11***t* have a shape extending in the Y direction. The plurality of top surface wirings **11***t* are arranged parallel to each other in the X direction. According to the configuration described above, since the top surface wirings **11***t* extend only in one direction, it is possible to form the fine narrow top surface wirings **11***t* and reduce the size of the inductor component **1** by using, for example, modified illumination in the photolithography process.

[0117] The bottom surface wirings **11***b* and the top surface wirings **11***t* are made of a good conductor material such as copper, silver, gold, or an alloy thereof. The bottom surface wirings **11***b* and the top surface wirings **11***t* may be a metal film formed by plating, vapor deposition, sputtering, or the like, or may be a metal sintered body obtained by applying and sintering a conductor paste. In addition, the bottom surface wirings **11***b* and the top surface wirings **11***t* may have a multilayer structure in which a plurality of metal layers are layered. The bottom surface wirings **11***b* and the top surface wirings **11***t* have a thickness of preferably 5 μm or more and 50 μm or less (i.e., from 5 μm to 50 μm).

[0118] The first penetration wirings **13** are disposed in through-holes V of the element body **10** on the first side surface **100***s***1** side with respect to the axis AX, and the second penetration wirings **14** are disposed in the other through-holes V of the element body **10** on the second side surface **100***s***2** side with respect to the axis AX. Each of the first penetration wirings **13** and the second penetration wirings **14** extends in a direction orthogonal to the bottom surface **100***b* and the top surface **100***t*. This enables lengths of the first penetration wirings **13** and the second penetration wirings **14** to be shortened, thus enabling the direct current resistance (Rdc) to be reduced. The plurality of first penetration wirings **13** and the plurality of second penetration wirings **14** are all arranged parallel to each other in the X direction.

[0119] Preferably, the first penetration wirings **13** contain SiO_2. This enables a linear expansion coefficient of the first penetration wiring **13** to be equal to a linear expansion coefficient of the element body **10** in a case where the element body **10** contains SiO_2, thus enabling cracks between the first penetration wirings **13** and the element body **10** to be reduced. The first penetration wiring **13** is made of, for example, a conductive paste. A conductive material is Ag, Cu, or the like. Similarly, the second penetration wirings **14** preferably contain SiO_2.

[0120] Preferably, the inner circumferential edge **131** of the first penetration wiring **13** has a convex curved portion. Consequently, it is possible to distribute stress applied to the curved portion of the inner circumferential edge **131** of the first penetration wiring **13**. The entire inner circumferential edge **131** is the curved portion; however, a part of the inner circumferential edge **131** may be a curved portion. The outer circumferential edge **132** of the first penetration wiring **13** is a straight line parallel to the axis AX, but may have a convex curved portion, and it is possible to distribute stress applied to the curved portion of the outer circumferential edge **132** of the first penetration wiring **13**. The side edge **133** of the first penetration wiring **13** is a straight line orthogonal to the axis AX.

[0121] Similarly, the inner circumferential edge **141** of the second penetration wiring **14** preferably has a convex curved portion. Consequently, it is possible to distribute stress applied to the curved portion of the inner circumferential edge **141** of the second penetration wiring **14**. The outer circumferential edge **142** of the second penetration wiring **14** is a straight line parallel to the axis AX. The side edge **143** of the second penetration wiring **14** is a straight line orthogonal to the axis AX.

[0122] Preferably, the length of the inner circumferential edge **131** of the first penetration wiring **13** is 1.5 times or more the length of the outer circumferential edge **132** of the first penetration wiring **13**. Consequently, it is possible to increase the length of the inner circumferential edge **131** of the first penetration wiring **13**, and it is possible to further decrease an electrical resistance value at a high frequency. That is, since a current flows spirally on an inner diameter side of the coil **110**, the electrical resistance decreases as the length of the inner circumferential edge **131** increases. For example, the length of the inner circumferential edge **131** is approximately 47 μm, and that of the outer circumferential edge **132** is approximately 30 μm. Regarding measurement of the lengths, WinRooF 2018 manufactured by MITANI CORPORATION is used, and it is possible to obtain a length of a circumferential edge (an inner circumferential edge and an outer circumferential edge) of a penetration wiring from an image diagram of a cross section. Note that, in the measurement of the inner circumferential edge and the outer circumferential edge, positions of both the inner circumferential edge and the outer circumferential edge to be measured may be designated. Note that a cross section to be measured is a cross section at a center of the first penetration wiring **13** in the extending direction.

[0123] Similarly, the length of the inner circumferential edge **141** of the second penetration wiring **14** is preferably 1.5 times or more the length of the outer circumferential edge **142** of the second penetration wiring **14**. Consequently, it is possible to increase the length of the inner circumferential edge **141** of the second penetration wiring **14**, and it is possible to further decrease an electrical resistance value at a high frequency.

[0124] Preferably, orientations of the curved portions of the inner circumferential edges **131** of all the first penetration wirings **13** are the same. The orientations of the curved portions are directions in which a midpoint of each curved portion and a center line of each first penetration wiring **13** are connected. The center line of the first penetration wiring **13** is a line passing through the center of gravity of the first penetration wiring **13** on a cross section orthogonal to an extending direction of the first penetration wiring **13**. Here, since the entire inner circumferential edge **131** is a curved portion, an orientation of the curved portion is a direction in which a midpoint of the inner circumferential edge **131** and a center line of the first penetration wiring **13** are connected. The orientation of the curved portion is a direction orthogonal to the axis AX. Note that, in the two first penetration wirings **13**, an orientation of the curved portion of the inner circumferential edge **131** of one first penetration wiring **13** may be different from an orientation of the curved portion of the inner circumferential edge **131** of the other first penetration wiring **13**. Consequently, it is possible to change the orientation of the curved portion of the first penetration wiring **13** depending on arrangement of the bottom surface wirings **11***b* and the top surface wirings **11***t*.

[0125] Similarly, the curved portions of the inner circumferential edges **141** of all the second penetration wirings **14** have preferably the same orientation. Note that, in the two second penetration wirings **14**, an orientation of the curved portion of the inner circumferential edge **141** of one second penetration wiring **14** may be different from an orientation of the curved portion of the inner circumferential edge **141** of the other second penetration wiring **14**.

[0126] FIG. **5** is an enlarged view of a part of FIG. **1**. As shown in FIG. **5**, when viewed in the direction orthogonal to the bottom surface **100***b*, a first end portion **11***b***1** of the bottom surface wiring **11***b* and a first end portion **13***a* of the first penetration wiring **13** are connected, and an outer shape of the coil **110** of the first end portion **11***b***1** of the bottom surface wiring **11***b* preferably conforms to an outer shape of the coil **110** of the first end portion **13***a* of the first penetration wiring **13**. The outer side of the coil **110** indicates the outer circumferential surface side of the coil **110**. To be more specific, an external shape of the first end portion **11***b***1** of the bottom surface wiring **11***b* conforms to the outer circumferential edge **132** and the side edge **133** of the first end portion **13***a* of the first penetration wiring **13**. According to the configuration described above, the shape of the first end portion **11***b***1** of the bottom surface wiring **11***b* can be made to correspond to the shape of the first end portion **13***a* of the first penetration wiring **13**, and it is possible to decrease the DC electrical resistance of a connection part between the bottom surface wiring **11***b* and the first penetration wiring **13**.

[0127] In this case, preferably, the first end portion **11***b***1** of the bottom surface wiring **11***b* is larger than the first end portion **13***a* of the first penetration wiring **13**. Consequently, even if misalignment of the bottom surface wiring **11***b* occurs, it is possible to ensure the connection between the bottom surface wiring **11***b* and the first penetration wiring **13**.

[0128] Similarly, when viewed in the direction orthogonal to the bottom surface **100***b*, preferably, a second end portion **11***b***2** of the bottom surface wiring **11***b* and a first end portion **14***a* of the second penetration wiring **14** are connected, and an outer shape of the coil **110** of the second end portion **11***b***2** of the bottom surface wiring **11***b* conforms to an outer shape of the coil **110** of the first end portion **14***a* of the second penetration wiring **14**.

[0129] To be more specific, an external shape of the second end portion **11***b***2** of the bottom surface wiring **11***b* conforms to the outer circumferential edge **142** and the side edge **143** of the first end portion **14***a* of the second penetration wiring **14**. According to the configuration described above, the shape of the second end portion **11***b***2** of the bottom surface wiring **11***b* can be made to correspond to the shape of the first end portion **14***a* of the second penetration wiring **14**, and it is possible to decrease the DC electrical resistance of a connection part between the bottom surface wiring **11***b* and the second penetration wiring **14**.

[0130] Preferably, as shown in FIG. **2**, when viewed in the direction orthogonal to the bottom surface **100***b*, the first end portion of the bottom surface wiring **11***b* and the first end portion of the top surface wiring **11***t* overlap each other, and an angle θ formed by the bottom surface wiring **11***b* and the top surface wiring **11***t* is an acute angle. The angle θ is an angle between a center line (a chain line in FIG. **2**) of a width of the bottom surface wiring **11***b* and a center line (a chain line in FIG. **2**) of a width of the top surface wiring **11***t* when viewed in the direction orthogonal to the bottom surface **100***b*.

[0131] Preferably, as shown in FIG. **2**, when viewed in the direction orthogonal to the bottom surface **100***b*, the angle θ formed by the bottom surface wiring **11***b* and the top surface wiring **11***t* connected to the same first penetration wiring **13** is 5° or larger and 45° or smaller (i.e., from 5° to) 45°. The angle θ is an angle between a center line (a chain line in FIG. **2**) of a width of the bottom surface wiring **11***b* and a center line (a chain line in FIG. **2**) of a width of the top surface wiring **11***t* when viewed in the direction orthogonal to the bottom surface **100***b*.

[0132] According to the configuration described above, since the coils **110** are densely wound, it is possible to improve the inductance. Since the angle θ is 45° or smaller, a coil length is shortened, the leakage flux is reduced, and the Q value is increased. The coil length indicates an interval between both end parts positioned on the outermost sides in the axis AX direction, among the bottom surface wirings **11***b*, the top surface wirings **11***t*, the first penetration wirings **13**, and the second penetration wirings **14**. Since the angle θ is 5° or larger, it is possible to decrease possibilities that the two first penetration wirings **13** adjacent to each other in the axis AX direction are brought into contact with each other, and it is possible to decrease possibilities that the two second penetration wirings **14** adjacent to each other in the axis AX direction are brought into contact with each other. Of all the bottom surface wirings **11***b* and the top surface wirings **11***t*, the angle θ between at least one set of the bottom surface wiring **11***b* and the top surface wiring **11***t* may be 5° or larger and 45° or smaller (i.e., from 5° to) 45°.

[0133] Preferably, similarly when viewed in the direction orthogonal to the bottom surface **100***b*, the angle θ formed by the bottom surface wiring **11***b* and the top surface wiring **11***t* connected to the same second penetration wiring **14** is 5°

or larger and 45° or smaller (i.e., from 5° to) 45°. Consequently, since the coils **110** are densely wound, it is possible to improve the inductance.

[0134] Preferably, at least one wiring of the bottom surface wirings **11***b*, the top surface wirings **11***t*, the first penetration wirings **13**, and the second penetration wirings **14** includes a void portion or a resin portion. This enables stress due to a difference in linear expansion coefficient between the wiring and the element body **10** to be absorbed by the void portion or the resin portion, thus enabling the stress to be alleviated. As a method of forming the void portion, for example, the void portion can be formed by sintering a wiring, by using a member which is burned into the material of the wiring by being sintered. As a method for forming the resin portion, for example, the resin portion can be formed by using a conductive paste in the material of the wiring.

[0135] Preferably, at least one wiring of the bottom surface wirings **11***b* and the top surface wirings **11***t* contains SiO_2. This enables a linear expansion coefficient of the wiring to be equal to the linear expansion coefficient of the element body **10** in a case where the element body **10** contains SiO_2, thus enabling cracks between the wiring and the element body **10** to be reduced.

(First External Electrode **121** and Second External Electrode **122**)

[0136] The first external electrode **121** is connected to the first end portion of the coil **110**, and the second external electrode **122** is connected to the second end portion of the coil **110**. The first external electrode **121** is provided on the first end surface **100***e***1** side with respect to a center of the element body **10** in the X direction to be exposed from the outer surface **100** of the element body **10**. The second external electrode **122** is provided on the second end surface **100***e***2** side with respect to a center of the element body **10** in the X direction to be exposed from the outer surface **100** of the element body **10**.

[0137] When viewed in the direction orthogonal to the bottom surface **100***b*, the first external electrode **121** and the second external electrode **122** are positioned on an inner side with respect to the outer surface **100** of the element body **10**. That is, the first external electrode **121** and the second external electrode **122** are positioned on an inner side with respect to the first end surface **100***e***1**, the second end surface **100***e***2**, the first side surface **100***s***1**, and the second side surface **100***s***2** of the element body **10**.

[0138] According to the configuration described above, since the first external electrode **121** and the second external electrode **122** are not in contact with the outer surfaces **100** of the element body **10**, loads applied to the first external electrode **121** and the second external electrode **122** can be decreased, and deformation and peeling of the first external electrode **121** and the second external electrode **122** can be reduced, when division into individual inductor components is performed. Therefore, even if the inductor component has a small size, it is possible to prevent the first external electrode **121** and the second external electrode **122** from being deformed or peeled off.

[0139] Note that the first external electrode **121** may be provided to be continuously connected to the bottom surface **100***b* and the first end surface **100***e***1**. This enables a solder fillet to be formed on the first external electrode **121** when the inductor component **1** is mounted on a mounting substrate, since the first external electrode **121** is a so-called L-shaped electrode. Similarly, the second external electrode **122** may be provided to be continuously connected to the bottom surface **100***b* and the second end surface **100***e***2**.

[0140] The first external electrode **121** has a bottom surface part **121***b* provided on the bottom surface **100***b* and a via part **121***v* embedded in the bottom surface **100***b*. The via part **121***v* is connected to the bottom surface part **121***b*. The via part **121***v* is connected to an end portion of the bottom surface wiring **11***b* positioned on the first end surface **100***e***1** side in the axis AX direction.

[0141] The second external electrode **122** has a bottom surface part **122***b* provided on the bottom surface **100***b* and a via part **122***v* embedded in the bottom surface **100***b*. The via part **122***v* is connected to the bottom surface part **122***b*. The via part **122***v* is connected to an end portion of the bottom surface wiring **11***b* positioned on the second end surface **100***e***2** side in the axis AX direction.

[0142] The first external electrode **121** has a base layer **121***e***1** and a plating layer **121***e***2** covering the base layer **121***e***1**. The base layer **121***e***1** contains, for example, a conductive material such as Ag or Cu. The plating layer **121***e***2** contains, for example, a conductive material such as Ni or Sn. A part of the bottom surface part **121***b* and the via part **121***v* are formed by the base layer **121***e***1**. The other part of the bottom surface part **121***b* is formed by the plating layer **121***e***2**. Similarly, the second external electrode **122** has a base layer and a plating layer covering the base layer. Note that the first external electrode **121** and the second external electrode **122** may be made of a single-layer conductor material.

(Method for Manufacturing Inductor Component **1**)

[0143] Next, a method for manufacturing the inductor component **1** will be described with reference to FIGS. **6**A to **6**M. FIGS. **6**A to **6**H, **6**K, and **6**L are views corresponding to a cross section taken along line II-II in FIG. **1**. FIGS. **6**I, **6**J, and **6**M are views corresponding to a cross section taken along line III-III in FIG. **1**.

[0144] As shown in FIG. **6**A, a first insulating layer **1011** is printed on a base substrate **1000**. Examples of materials of the base substrate **1000** include a glass substrate, a silicon substrate, an alumina substrate, or the like, and examples of materials of the first insulating layer **1011** include a resin such as epoxy or polyimide, or an inorganic insulating film such as SiO or SiN.

[0145] As shown in FIG. **6**B, a second insulating layer **1012** is printed on the first insulating layer **1011**. A groove **1012***a* is provided in the second insulating layer **1012**. In this case, for example, the groove **1012***a* is formed by the photolithography process. Note that the groove may be formed as a printed pattern from the beginning.

[0146] As shown in FIG. **6**C, a top surface conductor layer **1011***t* is printed in the groove **1012***a*. Examples of materials of the top surface conductor layer **1011***t* include Ag, Cu, Au, Al, an alloy containing at least one of these elements, or a solder paste. In this case, for example, the top surface conductor layer **1011***t* is formed as a printed pattern to remain only in the groove **1012***a*. Note that, after the top surface conductor layer **1011***t* is printed on the second insulating layer **1012**, the top surface conductor layer **1011***t* may remain only in the groove **1012***a* by the photolithography process.

[0147] As shown in FIG. **6**D, a third insulating layer **1013** is printed on the second insulating layer **1012**. The third insulating layer **1013** has a first groove **1013***a* and a second groove **1013***b*. The first groove **1013***a* and the second groove **1013***b* are formed in the same method as described in FIG. **6**B.

[0148] As shown in FIG. **6**E, a first penetration conductor layer **1131** as a first layer is printed in the first groove **1013***a*, and a second penetration conductor layer **1141** as the other first layer is printed in the second groove **1013***b*. The first penetration conductor layer **1131** as the first layer and the second penetration conductor layer **1141** as the other first layer are formed by the same method described in FIG. **6**C.

[0149] By repeating the above-described processes, as shown in FIG. **6**F, a fourth insulating layer **1014** is provided on the third insulating layer **1013**, and a first penetration conductor layer **1132** as a second layer and a second penetration conductor layer **1142** as the other second layer are provided in two respective grooves provided in the fourth insulating layer **1014**. Further, a fifth insulating layer **1015** is provided on the fourth insulating layer **1014**, and a first penetration conductor layer **1133** as a third layer and a second penetration conductor layer **1143** as the other third layer are provided in two respective grooves provided in the fifth insulating layer **1015**.

[0150] As shown in FIG. **6**G, a sixth insulating layer **1016** is provided on the fifth insulating layer **1015**, and a bottom surface conductor layer **1011***b* is provided in a groove provided in the sixth insulating layer **1016**. A material of the bottom surface conductor layer **1011***b* is the same as the material of the top surface conductor layer **1011***t*. As shown in FIG. **6**H, a seventh insulating layer **1017** is provided on the sixth insulating layer **1016**.

[0151] As shown in FIG. **6**I, a groove **1017***a* is provided in the seventh insulating layer **1017** such that a part of the bottom surface conductor layer **1011***b* is exposed. As shown in FIG. **6**J, a base conductor layer **1121***e***1** is provided on the seventh insulating layer **1017** and in the groove **1017***a*. Examples of materials of the base conductor layer **1121***e***1** include resin pastes of Ag or Cu.

[0152] As shown in FIG. **6**K, an entire layered body is sintered in a furnace at a high temperature (for example, 500° C. or higher). The first to seventh insulating layers **1011** to **1017** are sintered to form the element body **10**, the top surface conductor layer **1011***t* is sintered to form the top surface wiring **11***t*, the bottom surface conductor layer **1011***b* is sintered to form the bottom surface wiring **11***b*, the first penetration conductor layers **1131** to **1133** as the first to third layers are sintered to form the first penetration wiring **13**, the second penetration conductor layers **1141** to **1143** as the first to third other layers are sintered to form the second penetration wiring **14**, and the base conductor layer **1121***e***1** is sintered to form the base layer **121***e***1**. Hence, it is possible to improve the strength by sintering the insulating layers, and a resin component which does not need to be contained in the conductor layers can be volatilized by sintering the conductor layers, and a conductor material contained in the conductor layers can be fused to realize high conductivity. The base substrate **1000** may be peeled off by decomposing a surface during sintering, may be mechanically removed by performing grinding or the like before and after the sintering, or may be chemically removed by performing etching or the like before and after the sintering.

[0153] As shown in FIG. **6**L, division into individual inductor components is performed along a cutting line C. As shown in FIG. **6**M, the plating layer **121***e***2** is formed by performing barrel plating to cover the base layer **121***e***1**, and the first external electrode **121** is formed. Consequently, as shown in FIG. **2**, the inductor component **1** is manufactured.

3. MODIFICATION EXAMPLES

First Modification Example

[0154] FIG. **7**A is a view showing a first modification example of the inductor component, and the view corresponds to the cross section taken along line II-II in FIG. **1**. As shown in FIG. **7**A, in an inductor component **1**A of the first modification example, the first penetration wiring **13** and the second penetration wiring **14** are not parallel to each other when viewed in the direction parallel to the axis AX of the coil **110**. This enables a distance between the first penetration wiring **13** and the second penetration wiring **14** to be increased and enables the inner diameter of the coil **110** to be increased such that it is possible to improve the Q value.

[0155] To be more specific, the first penetration wiring **13** and the second penetration wiring **14** are bent at respective centers thereof in the Z direction such that a space therebetween is widened toward the centers. That is, each of the first penetration wiring **13** and the second penetration wiring **14** has a shape expanding outward in a radial direction of the coil **110** toward the center in the Z direction. In addition, each of the first penetration wiring **13** and the second penetration wiring **14** has a stepped shape in the Z direction. According to the configuration described above, in a case where the first penetration wiring **13** and the second penetration wiring **14** are each formed by layering a plurality of conductor layers, the first penetration wiring **13** and the second penetration wiring **14** can be easily formed in the stepped shape by shifting and layering each conductor layer.

Second Modification Example

[0156] FIG. **7**B is a view showing a second modification example of the inductor component, and the view corresponds to the cross section taken along line II-II in FIG. **1**. As shown in FIG. **7**B, in an inductor component **1**B of the second modification example, the first penetration wiring **13** and the second penetration wiring **14** are not parallel to each other when viewed in the direction parallel to the axis AX of the coil **110**. This enables a distance between the first penetration wiring **13** and the second penetration wiring **14** to be increased and enables the inner diameter of the coil **110** to be increased such that it is possible to improve the Q value.

[0157] To be more specific, the first penetration wirings **13** and the second penetration wirings **14** are inclined such that a space therebetween is widened toward the top surface wiring **11***t* side in the Z direction. That is, each of the first penetration wirings **13** and the second penetration wirings **14** has a shape expanding outward in the radial direction of the coil **110** toward the top surface wiring **11***t* in the Z direction. As described above, the coil **110** has a trapezoidal shape when viewed from the axis AX direction. According to the configuration described above, the first penetration wirings **13** and the second penetration wirings **14** can be linearly formed and shortened, and the DC resistance of the first penetration wirings **13** and the second penetration wirings **14** can be reduced.

Third Modification Example

[0158] FIG. **7**C is a view showing a third modification example of the inductor component, and the view corresponds to the cross section taken along line II-II in FIG. **1**. As shown in FIG. **7**C, an inductor component **1**C of the third modification example includes a first coil **110**A and a second coil **110**B as compared with the inductor component **1**A of the first modification example shown in FIG. **7**A.

[0159] In the first coil **110**A, the first penetration wiring **13** and the second penetration wiring **14** are not parallel to each other when viewed in the direction parallel to the axis AX. This enables a distance between the first penetration wiring **13** and the second penetration wiring **14** to be increased and enables the inner diameter of the coil **110**A to be increased such that it is possible to improve the Q value.

[0160] To be more specific, the first penetration wiring **13** has the same configuration as that of the first penetration wiring **13** of the inductor component **1**A of the first modification example. Meanwhile, the second penetration wiring **14** has a linear shape parallel to the Z direction. That is, the first penetration wiring **13** is bent at a center thereof in the Z direction such that a space between the first penetration wiring **13** and the second penetration wiring **14** is widened toward the center. The first penetration wiring **13** has a stepped shape in the Z direction. According to the configuration described above, in a case where the first penetration wiring **13** is formed by layering a plurality of conductor layers, the first penetration wiring **13** can be easily formed in the stepped shape by shifting and layering each conductor layer.

[0161] In the second coil **110**B, the first penetration wiring **13** and the second penetration wiring **14** are not parallel to each other when viewed in the direction parallel to the axis AX. This enables a distance between the first penetration wiring **13** and the second penetration wiring **14** to be increased and enables the inner diameter of the coil **110**B to be increased such that it is possible to improve the Q value.

[0162] To be more specific, the second penetration wiring **14** has the same configuration as that of the second penetration wiring **14** of the inductor component **1**A of the first modification example. Meanwhile, the first penetration wiring **13** has a linear shape parallel to the Z direction. That is, the second penetration wiring **14** is bent at a center thereof in the Z direction such that a space between the first penetration wiring **13** and the second penetration wiring **14** is widened toward the center. The second penetration wiring **14** has a stepped shape in the Z direction. According to the configuration described above, in a case where the second penetration wiring **14** is formed by layering a plurality of conductor layers, the second penetration wiring **14** can be easily formed in the stepped shape by shifting and layering each conductor layer.

Fourth Modification Example

[0163] FIG. **7**D is a view showing a fourth modification example of the inductor component, and the view corresponds to the cross section taken along line II-II in FIG. **1**. As shown in FIG. **7**D, an inductor component **1**D of the fourth modification example includes a first coil **110**A and a second coil **110**B as compared with the inductor component **1**B of the second modification example shown in FIG. **7**B.

[0164] In the first coil **110**A, the first penetration wiring **13** and the second penetration wiring **14** are not parallel to each other when viewed in the direction parallel to the axis AX. This enables a distance between the first penetration wiring **13** and the second penetration wiring **14** to be increased and enables the inner diameter of the coil **110**A to be increased such that it is possible to improve the Q value.

[0165] To be more specific, the first penetration wiring **13** has the same configuration as that of the first penetration wiring **13** of the inductor component **1**B of the second modification example. Meanwhile, the second penetration wiring **14** has a linear shape parallel to the Z direction. That is, the first penetration wiring **13** is inclined such that a space between the first penetration wiring **13** and the second penetration wiring **14** is widened toward the top surface wiring **11***t* side in the Z direction. According to the configuration described above, the first penetration wirings **13** and the second penetration wirings **14** can be linearly formed and shortened, and the DC resistance of the first penetration wirings **13** and the second penetration wirings **14** can be reduced.

[0166] In the second coil **110**B, the first penetration wiring **13** and the second penetration wiring **14** are not parallel to each other when viewed in the direction parallel to the axis AX. This enables a distance between the first penetration wiring **13** and the second penetration wiring **14** to be increased and enables the inner diameter of the coil **110**B to be increased such that it is possible to improve the Q value.

[0167] To be more specific, the second penetration wiring **14** has the same configuration as that of the second penetration wiring **14** of the inductor component **1**B of the second modification example. Meanwhile, the first penetration wiring **13** has a linear shape parallel to the Z direction. That is, the second penetration wiring **14** is inclined such that a space between the first penetration wiring **13** and the second penetration wiring **14** is widened toward the top surface wiring **11***t* side in the Z direction. According to the configuration described above, the first penetration wirings **13** and the second penetration wirings **14** can be linearly formed, and the electrical resistance of the first penetration wirings **13** and the second penetration wirings **14** can be reduced.

Second Embodiment

[0168] FIG. **8** shows a schematic bottom view of a second embodiment of the inductor component from a bottom surface side. FIG. **9** is a cross-sectional view taken along line IX-IX in FIG. **8**. In FIG. **8**, for convenience, an insulating layer is omitted, and the external electrodes are drawn by two-dot chain lines. In addition, in FIG. **8**, the element body **10** is drawn transparently so that a structure thereof can be easily understood. The second embodiment differs from the first embodiment mainly in the position of the axis of the coil, the orientation of the penetration wiring, the material of the element body, and providing of an insulating layer, and these different configurations will be mainly described below. The other configurations are the same as those of the first embodiment, and the description thereof will be omitted.

1. CONFIGURATIONS OF RESPECTIVE UNITS

(Inductor Component **1**E)

[0169] As shown in FIG. **8**, in an inductor component **1**E, an axis AX of a coil **110** is perpendicular to the X direction. To be more specific, the axis AX is parallel to the Y direction and passes a center of the element body **10** in the X direction. This enables interference in magnetic flux of the coil **110** by the first external electrode **121** and the second external electrode **122** to be reduced, and it is possible to improve the efficiency of acquisition of inductance.

[0170] A length of the coil **110** in the axis AX direction is shorter than an inner diameter of the coil **110**. The length of the coil **110** in the axis AX direction is also referred to as a coil length. This enables the Q value to be improved since the coil length is short and the coil inner diameter is large. The inner diameter of the coil indicates an equivalent circle diameter based on a minimum area of a region surrounded by the coil **110** when viewed therethrough in the axis AX direction.

(Element Body **10**)

[0171] The element body **10** is an inorganic insulating body. The material of the element body **10** is preferably glass, and this enables an eddy current to be reduced and enables the Q value to be increased since the glass has high insulation properties. The element body **10** preferably contains an Si element, and this enables the thermal stability of the element body **10** to be increased, thus, enabling variations in dimension or the like of the element body **10** due to heat to be reduced and enabling variations in electrical characteristics to be decreased.

[0172] The element body **10** is preferably a single-layer glass plate. This enables the strength of the element body **10** to be ensured. In addition, in the case of the single-layer glass plate, since dielectric loss is small, the Q value at a high frequency can be increased. In addition, since no sintering process for such a sintered body is performed, deformation of the element body **10** during sintering can be reduced. Hence, it is possible to reduce pattern misalignment and provide an inductor component with a small inductance tolerance.

[0173] As a material of the single-layer glass plate, a glass plate having photosensitivity represented by Foturan II (Schott AG's registered trademark) is preferable from the viewpoint of a manufacturing method. In particular, the single-layer glass plate preferably contains cerium oxide (ceria: CeO_2), and in this case, cerium oxide serves as a sensitizer, and processing by photolithography becomes easier.

[0174] However, since the single-layer glass plate can be processed by machining such as drilling or sandblasting, dry/wet etching using a photoresist/metal mask, laser processing, or the like, the single-layer glass plate may be a non-photosensitive glass plate. In addition, the single-layer glass plate may be obtained by sintering a glass paste, or may be formed by a known method such as a float process.

(Insulating Body **22**)

[0175] As shown in FIG. **9**, the inductor component **1**E includes an insulating body **22**. The insulating body **22** covers both the bottom surface **100***b* and the top surface **100***t* of the element body **10**. Note that the insulating body **22** may be provided only on the bottom surface **100***b* of the bottom and top surfaces **100***b* and **1100***t*.

[0176] The insulating body **22** is a member that protects the wirings from an external force by covering the wirings (the bottom surface wirings **11***b* and the top surface wirings **11***t*), and has a role of preventing the wirings from being damaged and a role of improving insulation properties of the wirings. The insulating body **22** is preferably an organic insulating body. For example, the insulating body **22** may be a film made of a resin such as epoxy or polyimide which is easily formed. In particular, the insulating body **22** is preferably made of a material having a low dielectric constant. Consequently, in a case where the insulating body **22** is present between the coil **110** and the external electrode **121** or **122**, it is possible to decrease the stray capacitance formed between the coil **110** and the external electrode **121** or **122**. The insulating body **22** can be formed, for example, by laminating a resin film such as ABF GX-92 (manufactured by Ajinomoto Fine-Techno Co., Inc.), applying and thermal-curing a paste-like resin, or the like. Note that the insulating body **22** may be, for example, an inorganic film made of an oxide such as silicon or hafnium, a nitride, an oxynitride, or the like, which is excellent in insulating properties and thinning.

[0177] Preferably, when the element body **10** is the inorganic insulating body, and the insulating body **22** is an organic insulating body, the organic insulating body is positioned on an inner side with respect to the outer surfaces **100** of the inorganic insulating body when viewed in the direction orthogonal to the bottom surface **100***b*. According to this, since the organic insulating body is provided, the organic insulating body easily imparts flowability, the organic insulating body easily fills a space between wirings adjacent to each other and enables insulating properties to be improved, in a case where the wirings (the bottom surface wirings **11***b* and the top surface wirings **11***t*) are covered with the organic insulating body. In addition, since the organic insulating body is not in contact with the outer surface of the inorganic insulating body, it is possible to decrease a load applied to the organic insulating body and reduce deformation and peeling of the organic insulating body when division into individual inductor components is performed.

(Coil **110**)

[0178] As shown in FIG. **8**, the bottom surface wiring **11***b* extends only in one direction. To be more specific, the bottom surface wirings **11***b* have a shape extending in the X direction. The plurality of bottom surface wirings **11***b* are arranged parallel to each other in the Y direction. The top surface wirings **11***t* extend only in one direction. To be more specific, the top surface wirings **11***t* slightly tilt in the Y direction and extend in the X direction. The plurality of top surface wirings **11***t* are arranged parallel to each other in the Y direction.

[0179] The first penetration wirings **13** are disposed in the through-holes V of the element body **10** on the first end surface **100***e***1** side with respect to the axis AX, and the second penetration wirings **14** are disposed in the other through-holes V of the element body **10** on the second end surface **100***e***2** side with respect to the axis AX. Each of the first penetration wirings **13** and the second penetration wirings **14** extends in a direction orthogonal to the bottom surface **100***b* and the top surface **100***t*. The plurality of first penetration wirings **13** and the plurality of second penetration wirings **14** are all arranged parallel to each other in the Y direction.

[0180] As shown in FIG. **9**, on a cross section orthogonal to an extending direction of the bottom surface wirings **11***b*, upper surfaces **11***b***3** of the bottom surface wirings **11***b* which are positioned on a side opposite to the axis AX preferably have a convex shape projecting upward on the side opposite to the axis AX. Consequently, it is possible to increase a distance between the upper surfaces **11**_b_**3** of two bottom surface wirings **11**_b_ adjacent to each other in the axis AX direction, and it is possible to decrease parasitic capacitance between the bottom surface wirings **11**_b_ adjacent to each other in the axis AX direction such that it is possible to increase the self-resonant frequency of the inductor component **1**E.

[0181] Similarly, on a cross section orthogonal to an extending direction of the top surface wirings **11**_t_, upper surfaces **11**_t_**3** of the top surface wirings **11**_t_ which are positioned on a side opposite to the axis AX preferably have a convex shape projecting upward on the side opposite to the axis AX. Consequently, it is possible to increase a distance between the upper surfaces **11**_t_**3** of two top surface wirings **11**_t_ adjacent to each other in the axis AX direction, and it is possible to decrease parasitic capacitance between the top surface wirings **11**_t_ adjacent to each other in the axis AX direction such that it is possible to increase the self-resonant frequency of the inductor component **1**E.

[0182] Preferably, the first external electrode **121** is disposed on the bottom surface wirings **11**_b_, and the upper surfaces **11**_b_**3** of the bottom surface wirings **11**_b_ are opposite to the first external electrode **121**. Consequently, it is possible to increase a distance between the upper surfaces **11**_b_**3** of the first external electrode **121** and the bottom surface wirings **11**_b_, and it is possible to decrease parasitic capacitance between the first external electrode **121** and the bottom surface wirings **11**_b_ such that it is possible to increase the self-resonant frequency of the inductor component **1**E.

[0183] Similarly, preferably, the second external electrode **122** is disposed on the bottom surface wirings **11**_b_, and the upper surfaces **11**_b_**3** of the bottom surface wirings **11**_b_ are opposite to the second external electrode **122**. Consequently, it is possible to increase a distance between the upper surfaces **11**_b_**3** of the second external electrode **122** and the bottom surface wirings **11**_b_, and it is possible to decrease parasitic capacitance between the second external electrode **122** and the bottom surface wirings **11**_b_ such that it is possible to increase the self-resonant frequency of the inductor component **1**E.

[0184] Note that the first external electrode **121** and the second external electrode **122** may not be disposed immediately on the bottom surface wirings **11**_b_, and may be slightly separated from the bottom surface wirings **11**_b_ when viewed in the direction orthogonal to the bottom surface **100**_b_. Even in this case, it is possible to decrease the parasitic capacitance between the first external electrode **121** and the second external electrode **122** and the bottom surface wiring **11**_b_.

[0185] FIG. **10** is a schematic bottom view of the coil **110** from the bottom surface **100**_b_ side. As shown in FIG. **10**, when viewed in the direction orthogonal to the bottom surface **100**_b_, a bisector (hereinafter, referred to as a first bisector L**1**) of a first angle θ**1** formed by the bottom surface wiring **11**_b_ and the top surface wiring **11**_t_ connected to a reference first penetration wiring **13**A which is one of the first penetration wirings **13** is defined.

[0186] As shown in FIG. **11**, on a cross section parallel to the bottom surface **100**_b_ and including the axis AX, the reference first penetration wiring **13**A has an inner circumferential edge **131** facing the first bisector L**1** side and an outer circumferential edge **132** facing a side opposite to the first bisector L**1**. The length of the inner circumferential edge **131** is longer than the length of the outer circumferential edge **132**.

[0187] The inner circumferential edge **131** is a region on an entire circumferential edge of the reference first penetration wiring **13**A which is projected on an orthogonal line Lr, when the reference first penetration wiring **13**A is projected toward the orthogonal line Lr orthogonal to the first bisector L**1** in a direction parallel to the first bisector L**1**. The outer circumferential edge **132** is a region on the entire circumferential edge of the reference first penetration wiring **13**A which is projected on a virtual line Lv, when the virtual line Lv is defined to be parallel to the orthogonal line Lr on a side opposite to the orthogonal line Lr with respect to the reference first penetration wiring **13**A, and the reference first penetration wiring **13**A is projected toward the virtual line Lv in a direction parallel to the first bisector L**1**.

[0188] According to the configuration described above, since a length of the inner circumferential edge **131** is longer than a length of the outer circumferential edge **132**, it is possible to increase a surface area of an inner surface of the reference first penetration wiring **13**A. Consequently, it is possible to increase the surface area of the inner surface of the coil **110** such that the electrical resistance value at the high frequency is decreased, and the Q value at the high frequency is improved. Note that all the first penetration wirings **13** may have the same configuration as that of the reference first penetration wiring **13**A.

[0189] Similarly, as shown in FIG. **10**, when viewed in the direction orthogonal to the bottom surface **100**_b_, a bisector (hereinafter, referred to as a second bisector L**2**) of a second angle θ**2** formed by the bottom surface wiring **11**_b_ and the top surface wiring **11**_t_ connected to a reference second penetration wiring **14**A which is one of the second penetration wirings **14** is defined.

[0190] As shown in FIG. **11**, on a cross section parallel to the bottom surface **100**_b_ and including the axis AX, the reference second penetration wiring **14**A has an inner circumferential edge **131** facing the second bisector L**2** side and an outer circumferential edge **132** facing a side opposite to the second bisector L**2**. The length of the inner circumferential edge **131** is longer than the length of the outer circumferential edge **132**. Consequently, it is possible to increase a surface area of an inner surface of the reference second penetration wiring **14**A such that it is possible to further increase the surface area of the inner surface of the coil **110**, the electrical resistance value at a high frequency is further decreased, and the Q value at the high frequency is further improved. Note that all the second penetration wirings **14** may have the same configuration as that of the reference second penetration wiring **14**A.

[0191] Preferably, an orientation of a curved portion of the inner circumferential edge **131** of the reference first penetration wiring **13**A coincides with the first bisector L**1**. Here, since the entire inner circumferential edge **131** is a curved portion, an orientation of the curved portion is a direction in which a midpoint of the inner circumferential edge **131** and a center line of the first penetration wiring **13** are connected. Note that all the first penetration wirings **13** may have the same configuration as that of the reference first penetration wiring **13**A.

[0192] Preferably, an orientation of a curved portion of the inner circumferential edge **131** of the reference second penetration wiring **14**A coincides with the second bisector

L**2**. Here, since the entire inner circumferential edge **131** is a curved portion, an orientation of the curved portion is a direction in which a midpoint of the inner circumferential edge **131** and a center line of the second penetration wiring **14** are connected. Note that all the second penetration wirings **14** may have the same configuration as that of the reference second penetration wiring **14**A.

[0193] Note that angles formed by all the bottom surface wirings **11***b* and the top surface wirings **11***t* may be different from each other, and in this case, all the bisectors are not parallel to each other. In addition, orientations of the curved portions of the inner circumferential edges **131** of all the first penetration wirings **13** may be the same as or different from each other. Orientations of the curved portions of the inner circumferential edges **141** of all the second penetration wirings **14** may be the same as or different from each other.

(Method for Manufacturing Inductor Component **1**E)

[0194] Next, a method for manufacturing the inductor component **1**E will be described with reference to FIGS. **12**A to **12**H. FIGS. **12**A to **12**H are views corresponding to a cross section taken along line IX-IX in FIG. **8**.

[0195] As shown in FIG. **12**A, copper foil **2001** is printed on a base substrate **2000**. A material of the base substrate **2000** is the same as that of the base substrate **1000** of the first embodiment.

[0196] As shown in FIG. **12**B, a glass substrate **2010** which becomes the element body **10** is provided on the base substrate **2000**. For example, the base substrate **2000** and the glass substrate **2010** are brought into close contact with each other using a jig such as a conductive tape, a pin, or a frame. The glass substrate **2010** has a through-hole V. The glass substrate **2010** is, for example, a through glass via (TGV) substrate. The TGV substrate is a substrate in which a through-hole is formed in advance by a laser, photolithography, or the like. The glass substrate **2010** may be, for example, a through silicon via (TSV) substrate, or may be another substrate. In addition, Ti/Cu or other necessary conductive materials may be deposited on a surface of the glass substrate **2010** in advance as seeds by sputtering or the like.

[0197] As shown in FIG. **12**C, a first penetration conductor layer **2013** which becomes the first penetration wiring **13** is formed in the through-hole V of the glass substrate **2010**. Although not shown, similarly, a second penetration conductor layer which becomes the second penetration wiring **14** is formed in the through-hole V. To be more specific, by supplying electric power from the copper foil **2001** on the base substrate **2000**, electrolytic plating is performed on the through-hole V of the glass substrate **2010** to form the first penetration conductor layer **2013**. Otherwise, a seed layer may be formed on the surface of the glass substrate **2010** or an inner surface of the through-hole V by sputtering or the like, and the penetration conductor layer may be formed by using a known method such as fill plating, conformal plating, or a printing filling method of a conductive paste. In a case where there is unnecessary plating growth on the surface of the glass substrate **2010**, an unnecessary part is removed by polishing, CMP, wet etching (etchback), or dry etching.

[0198] As shown in FIG. **12**D, the base substrate **2000** is peeled off from the glass substrate **2010**. In this case, the base substrate **2000** may be mechanically removed by grinding or the like, or may be chemically removed by etching or the like.

[0199] As shown in FIG. **12**E, a bottom surface conductor layer **2011***b* which becomes the bottom surface wiring **11***b* and a top surface conductor layer **2011***t* which becomes the top surface wiring **11***t* are formed on the glass substrate **2010**. To be more specific, a seed layer (not shown) is provided on the entire surface of the glass substrate **2010**, and patterned photoresist is formed on the seed layer. A copper layer is formed on the seed layer in an opening portion of the photoresist by electrolytic plating. The photoresist and the seed layer are removed by wet etching or dry etching. Consequently, the bottom surface conductor layer **2011***b* and the top surface conductor layer **2011***t* patterned in an arbitrary shape are formed. In this case, the bottom surface conductor layer **2011***b* and the top surface conductor layer **2011***t* may be formed one by one, or may be formed simultaneously. In addition, shapes of the upper surfaces of the top surface wirings and the bottom surface wirings may be formed into convex curved surfaces by optimizing agitation conditions of an additive and an electrolytic plating solution.

[0200] As shown in FIG. **12**F, an insulating layer **2022** serving as the insulating body **22** is provided on a top surface and a bottom surface of the glass substrate **2010** to cover the conductor layer. In this case, the insulating layer **2022** on the bottom surface side and the insulating layer **2022** on the top surface side may be formed one by one, or may be formed simultaneously. Thereafter, a hole **2022***a* is formed in the bottom surface conductor layer **2011***b* of the insulating layer **2022** on the bottom surface side by photolithography or laser processing.

[0201] As shown in FIG. **12**G, a first external electrode conductor layer **2121** which becomes the first external electrode **121** is provided on the insulating layer **2022** on the bottom surface side. In this case, the first external electrode conductor layer **2121** is connected to the bottom surface conductor layer **2011***b* via the hole **2022***a*. To be more specific, a Pd catalyst (not shown) is provided on the insulating layer **2022** on the bottom surface side, and an Ni/Au plated layer is formed by electroless plating. Patterned photoresist is formed on the plating layer. A plating layer in an opening portion of the photoresist is removed by wet etching or dry etching. Consequently, the first external electrode conductor layer **2121** patterned in an arbitrary shape is formed. Alternatively, a seed layer (not shown) is provided on the insulating layer **2022** on the bottom surface side, and the patterned photoresist is formed on the seed layer. Next, the seed layer in the opening portion of the photoresist is removed by wet etching or dry etching. An Ni/Au plating layer may be formed on the remaining seed layer by electroless plating. Although not shown, a second external electrode conductor layer which becomes the second external electrode **122** is provided on the insulating layer **2022** on the bottom surface side.

[0202] Here, since the first external electrode conductor layer **2121** is formed to conform to a shape of an upper surface of the insulating layer **2022** on the bottom surface side, an upper surface of the first external electrode conductor layer **2121** has a recess in a region overlapping the hole **2022***a*. Note that the first external electrode conductor layer **2121** may be formed to have a flat upper surface.

[0203] As shown in FIG. **12**H, division into individual components is performed along the cutting line C. Consequently, as shown in FIG. **9**, the inductor component **1**E is manufactured.

2. MODIFICATION EXAMPLES

First Modification Example

[0204] FIG. **13**A is a view showing a first modification example of the inductor component, and the view corresponds to the cross section taken along line IX-IX in FIG. **8**. As shown in FIG. **13**A, in an inductor component **1**F of the first modification example, the first external electrode **121** is not connected to the bottom surface wiring **11***b* but is connected to the first penetration wiring **13**. That is, a first end portion of the corresponding first penetration wiring **13** is connected to the first external electrode **121**, and a second end portion of the corresponding first penetration wiring **13** is connected to the top surface wiring **11***t*. This enables the coil to be easily connected to the first external electrode **121** even when the number of turns of the coil is changed. Similarly, the second external electrode **122** may be connected to the second penetration wiring **14**, instead of the bottom surface wiring **11***b*.

Second Modification Example

[0205] FIG. **13**B is a view showing a second modification example of the inductor component, and the view corresponds to the cross section taken along line IX-IX in FIG. **8**. As shown in FIG. **13**B, in an inductor component **1**G of the second modification example, the first penetration wiring **13** extends in a direction orthogonal to the bottom surface wiring **11***b*, and a cross-sectional area of each of both end portions **13***e* of the first penetration wiring **13** in an extending direction thereof is larger than a cross-sectional area of a central portion **13***m* of the first penetration wiring **13** in the extending direction. That is, in a cross section of the first penetration wiring **13** in the extending direction, a width of the first penetration wiring **13** in a direction orthogonal to the extending direction continuously increases from the central portion **13***m* toward both the end portions **13***e*.

[0206] This enables the cross-sectional area of the end portion **13***e* of the first penetration wiring **13** to be increased, so that the connectivity between the first penetration wiring **13** and at least one of the bottom surface wiring **11***b* and the top surface wiring **11***t* can be improved. In addition, when the through-hole V is formed as a hole portion in the element body **10**, the through-hole V is filled with a conductive material by fill plating or the like, and the first penetration wiring **13** is formed in the through-hole V, it is easy to fill the through-hole V on an opening side with the conductive material. Since the cross-sectional area of the end portion **13***e* of the first penetration wiring **13** is large, and the cross-sectional area of the central portion **13***m* of the first penetration wiring **13** is small, the first penetration wiring **13** is easily formed.

[0207] Note that the cross-sectional area of one end portion **13***e* of the first penetration wiring **13** may be larger than the cross-sectional area of the central portion **13***m* of the first penetration wiring **13**. Similarly, the cross-sectional area of at least one end portion of the second penetration wiring **14** may be larger than the cross-sectional area of the central portion **13***m* of the first penetration wiring **13**.

Third Modification Example

[0208] FIG. **13**C is a view showing a third modification example of the inductor component, and the view corresponds to the cross section taken along line IX-IX in FIG. **8**. As shown in FIG. **13**C, in an inductor component **1**H of the third modification example, the first penetration wiring **13** includes a conductive layer **13***s* positioned on an outer circumferential side thereof when viewed from an extending direction of the first penetration wiring **13**, and a non-conductive layer **13***u* positioned inside the conductive layer **13***s*. This prevents the Q value from being reduced by providing the conductive layer **13***s* on the outer circumferential side since a current mainly flows in a surface of the first penetration wiring **13** due to a skin effect in the case of use in a high frequency band. In addition, by providing the non-conductive layer **13***u* inside, stress can be alleviated, and manufacturing costs can be reduced by using no conductor.

[0209] An example of a method of forming the conductor layer **13***s* and the non-conductive layer **13***u* will be described. A seed layer is provided on the inner surface of the through-hole V of the element body **10** by sputtering or electroless plating. A plating layer is formed on the seed layer by electrolytic plating. In this manner, for example, a plurality of conductive layers **13***s* of Ti/Cu/electrolytic Cu, Pd/electroless Cu/electrolytic Cu, or the like can be formed on the first penetration wiring **13** on the outer circumferential side thereof. Thereafter, the inside of the conductive layer **13***s* is sealed with a resin by printing, hot pressing, or the like to form the non-conductive layer **13***u* made of a resin. In this manner, stress can be alleviated by the non-conductive layer **13***u* inside the first penetration wiring **13** while a current flows in the surface (the conductive layer **13***s*) of the first penetration wiring **13**.

[0210] Similarly, the second penetration wiring **14** may include a conductive layer positioned on an outer circumferential side thereof when viewed from an extending direction of the second penetration wiring **14**, and a non-conductive layer positioned inside the conductive layer.

Third Embodiment

[0211] FIG. **14** is an XY cross-sectional view showing a first penetration wiring of a third embodiment of the inductor component. The third embodiment differs from the first embodiment (FIG. **4**) in that the inner circumferential edges and the outer circumferential edges of the first penetration wirings are different from those therein, and the different configuration will be described below. The other configurations are the same as those of the first embodiment, and the description thereof will be omitted.

[0212] As shown in FIG. **14**, in an inductor element **1**I of the third embodiment, on a cross section parallel to the bottom surface **100***b* and including the axis AX, a first penetration wiring **13**I has an inner circumferential edge **131** parallel to the axis AX and facing the axis AX side and an outer circumferential edge **132** parallel to the axis AX and facing a side opposite to the axis AX. The length of the inner circumferential edge **131** is longer than the length of the outer circumferential edge **132**. Consequently, since a length of the inner circumferential edge **131** is longer than a length of the outer circumferential edge **132**, it is possible to increase a surface area of an inner surface of the first penetration wiring **13**I. Hence, it is possible to increase the surface area of the inner surface of the coil such that the electrical resistance value at the high frequency is decreased, and the Q value at the high frequency is improved.

[0213] The first penetration wiring **13**I further includes a side edge **133** that connects the inner circumferential edge **131** and the outer circumferential edge **132** to each other. The side edge **133** is a straight line and is inclined with respect to the direction orthogonal to the axis AX. The side edge **133** faces the side opposite to the axis AX. A space between both the side edges **133** increases from the outer circumferential edge **132** toward the inner circumferential edge **131**. That is, the first penetration wiring **13**I has a trapezoidal cross-sectional shape. The side edge **133** may have a curved shape instead of a straight line shape.

[0214] In addition, although not shown, the second penetration wiring may have the same configuration as that of the first penetration wiring **13**I, and has the same operation and effects as those of the first penetration wiring **13**I described above.

Fourth Embodiment

[0215] FIG. **15** is an XY cross-sectional view showing a first penetration wiring of a fourth embodiment of the inductor component. The fourth embodiment differs from the second embodiment (FIG. **11**) in that the inner circumferential edge and the outer circumferential edge of the reference first penetration wiring are different from those therein, and the different configuration will be described below. The other configurations are the same as those of the second embodiment, and the description thereof will be omitted.

[0216] As shown in FIG. **15**, in the inductor component **1**J according to the fourth embodiment, when the bisector L**1** of the angle θ formed by the bottom surface wiring **11***b* and the top surface wiring **11***t* connected to a reference first penetration wiring **13**J is defined when viewed in the direction orthogonal to the bottom surface **100***b*, on a cross section parallel to the bottom surface **100***b* and including the axis AX, a reference first penetration wiring **13**A has an inner circumferential edge **131** parallel to a direction orthogonal to the bisector L**1** and facing the bisector L**1** side, and an outer circumferential edge **132** parallel to the direction orthogonal to the bisector L**1** and facing a side opposite to the bisector L**1**. The length of the inner circumferential edge **131** is longer than the length of the outer circumferential edge **132**. Consequently, since a length of the inner circumferential edge **131** is longer than a length of the outer circumferential edge **132**, it is possible to increase a surface area of an inner surface of the reference first penetration wiring **13**J. Hence, it is possible to increase the surface area of the inner surface of the coil such that the electrical resistance value at the high frequency is decreased, and the Q value at the high frequency is improved.

[0217] The reference first penetration wiring **13**J further includes a side edge **133** that connects the inner circumferential edge **131** and the outer circumferential edge **132** to each other. The side edge **133** is a straight line and is inclined with respect to the bisector L**1**. The side edge **133** faces the side opposite to the bisector L**1**. The space between both the side edges **133** increases from the outer circumferential edge **132** toward the inner circumferential edge **131**. That is, the reference first penetration wiring **13**J has a trapezoidal cross-sectional shape. The side edge **133** may have a curved shape instead of a straight line shape.

[0218] Note that all the first penetration wirings may have the same configuration as that of the reference first penetration wiring **13**A. In addition, although not shown, the reference second penetration wiring may have the same configuration as that of the reference first penetration wiring **13**J, and has the same operation and effects as those of the first penetration wiring **13**J described above. In this case, all the second penetration wirings may have the same configuration as that of the reference second penetration wiring.

[0219] Note that the present disclosure is not limited to the embodiments described above, and can be modified in design without departing from the gist of the present disclosure. For example, the individual characteristic points of the first to fourth embodiments may be variously combined.

[0220] In the first embodiment and the second embodiment, the first penetration wiring has the inner circumferential edge, the outer circumferential edge, and the side edge, but may include only the inner circumferential edge and the outer circumferential edge without having the side edge. In this case, the inner circumferential edge and the outer circumferential edge may be convex curves, and for example, the curvature radius of the inner circumferential edge is larger than the curvature radius of the outer circumferential edge. In addition, the inner circumferential edge and the outer circumferential edge may be concave curves. In addition, the second penetration wiring may be the same as the first penetration wiring.

[0221] The present disclosure includes the following aspects.

[0222] <1> An inductor component including an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, on a cross section parallel to the first principal surface and including the axis, the first penetration wirings have respective inner circumferential edges facing the axis side and respective outer circumferential edges facing a side opposite to the axis, and the inner circumferential edges have a length longer than a length of the outer circumferential edges.

[0223] <2> An inductor component including an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, when a bisector of an angle formed by each of the first coil wirings and each of the second coil wirings connected to a reference first penetration wiring that is one of the first penetration wirings is defined when viewed in a direction orthogonal to the first principal surface, on a cross section parallel to the first principal surface and including the axis, the reference first penetration wiring has an inner circumferential edge facing the bisector side and an outer circumferential edge facing a side opposite to the bisector, and the inner circumferential edge has a length longer than a length of the outer circumferential edge.

[0224] <3> An inductor component including an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, on a cross section parallel to the first principal surface and including the axis, each of the first penetration wirings has an inner circumferential edge which is parallel to the axis and faces the axis side and an outer circumferential edge which is parallel to the axis and faces a side opposite to the axis, and a length of the inner circumferential edge is longer than a length of the outer circumferential edge.

[0225] <4> An inductor component including an element body having a first principal surface and a second principal surface opposite to each other; a coil that is provided in the element body and is wound in a spiral shape along an axis; and a first external electrode and a second external electrode that are provided on the element body and are electrically connected to the coil. The axis of the coil is disposed parallel to the first principal surface. The coil includes a plurality of first coil wirings which are provided on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface, a plurality of second coil wirings which are provided on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface, a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are provided on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis. Each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings form at least a part of the spiral shape by being connected in this order. Also, when a bisector of an angle formed by each of the first coil wirings and each of the second coil wirings connected to a reference first penetration wiring that is one of the first penetration wirings is defined when viewed in a direction orthogonal to the first principal surface, on a cross section parallel to the first principal surface and including the axis, the reference first penetration wiring has an inner circumferential edge parallel to a direction orthogonal to the bisector and facing the bisector side and an outer circumferential edge parallel to the direction orthogonal to the bisector and facing a side opposite to the bisector, and the inner circumferential edge has a length longer than a length of the outer circumferential edge.

[0226] <5> The inductor component according to any one of <1> to <4>, in which the element body contains SiO_2.

[0227] <6> The inductor component according to <1> or <2>, in which the inner circumferential edges of the first penetration wirings have respective convex curved portions.

[0228] <7> The inductor component according to <6>, in which the plurality of first penetration wirings include two of the first penetration wirings in which orientations of the curved portions of the inner circumferential edges are different from each other.

[0229] <8 The inductor component according to any one of <1> to <7>, in which the inner circumferential edges of the first penetration wirings have a length which is 1.5 times or more a length of the outer circumferential edges of the first penetration wirings.

[0230] <9> The inductor component according to any one of <1> to <8>, in which, when viewed in the direction orthogonal to the first principal surface, a first end portion of each of the first coil wirings is connected to a first end portion of each of the first penetration wirings, and an outer shape of the coil of the first end portion of each of the first coil wirings conforms to an outer shape of the coil of the first end portion of each of the first penetration wirings.

[0231] <10> The inductor component according to any one of <1> to <9>, in which, when viewed in the direction orthogonal to the first principal surface, an angle formed by each of the first coil wirings and each of the second coil wirings connected to the same first penetration wiring is 5° or larger and 45° or smaller (i.e., from 5° to) 45°.

[0232] <11> The inductor component according to any one of <1> to <10>, in which, on a cross section orthogonal to an extending direction of the first coil wirings, upper surfaces of the first coil wirings positioned on a side opposite to the axis have a convex shape protruding upward on a side opposite to the axis.

[0233] <12> The inductor component according to <11>, in which the first external electrode is disposed on the first coil wirings, and the upper surfaces of the first coil wirings face the first external electrode.

[0234] <13> The inductor component according to any one of <1> to <12>, in which, when viewed in a direction parallel to the axis, the first penetration wirings and the second penetration wirings are not parallel to each other.

[0235] <14> The inductor component according to any one of <1> to <13>, in which the element body contains SiO_2, and the first penetration wirings contain SiO_2.

[0236] <15> The inductor component according to any one of <1> to <14>, in which each of the first penetration wirings has a void portion or a resin portion.

[0237] <16> The inductor component according to any one of <1> to <15>, in which each of the first penetration wirings includes a conductive layer positioned on an outer circumferential side when viewed in an extending direction of the first penetration wirings, and a non-conductive layer positioned inside the conductive layer.

[0238] <17> The inductor component according to any one of <1> to <16>, in which a length of the coil in an axial direction is shorter than an inner diameter of the coil.

[0239] <18> The inductor component according to any one of <1> to <17>, in which the first penetration wirings extend in the direction orthogonal to the first principal surface, and a cross-sectional area of at least one of both end portions of each of the first penetration wirings in the extending direction is larger than a cross-sectional area of a central portion of each of the first penetration wirings in the extending direction.

[0240] <19> The inductor component according to any one of <1> to <18>, in which, when viewed in the direction orthogonal to the first principal surface, the first external electrode and the second external electrode are positioned on an inner side with respect to an outer surface of the element body.

[0241] <20> The inductor component according to any one of <1> to <19>, further including an organic insulating body provided on the first principal surface, in which the element body is an inorganic insulating body, and the organic insulating body is positioned on an inner side with respect to an outer surface of the inorganic insulating body when viewed in the direction orthogonal to the first principal surface.

What is claimed is:

1. An inductor component comprising:

an element body having a first principal surface and a second principal surface opposite to each other;

a coil that is in the element body and is wound in a spiral shape along an axis; and

a first external electrode and a second external electrode that are on the element body and are electrically connected to the coil, wherein

the axis of the coil is parallel to the first principal surface,

the coil includes

a plurality of first coil wirings which are on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface,

a plurality of second coil wirings which are on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface,

a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and

a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis,

each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings configure at least a part of the spiral shape by being connected in this order, and

on a cross section parallel to the first principal surface and including the axis, the first penetration wirings have respective inner circumferential edges facing the axis side and respective outer circumferential edges facing a side opposite to the axis, and the inner circumferential edges have a length longer than a length of the outer circumferential edges.

2. An inductor component comprising:

an element body having a first principal surface and a second principal surface opposite to each other;

a coil that is in the element body and is wound in a spiral shape along an axis; and

a first external electrode and a second external electrode that are on the element body and are electrically connected to the coil, wherein

the axis of the coil is parallel to the first principal surface,

the coil includes

a plurality of first coil wirings which are on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface,

a plurality of second coil wirings which are on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface,

a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and

a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis,

each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings configure at least a part of the spiral shape by being connected in this order, and when a bisector of an angle defined by each of the first coil wirings and each of the second coil wirings connected to a reference first penetration wiring that is one of the first penetration wirings is defined when viewed in a direction orthogonal to the first principal surface, on a cross section parallel to the first principal surface and including the axis, the reference first penetration wiring has an inner circumferential edge facing the bisector side and an outer circumferential edge facing a side opposite to the bisector, and the inner circumferential edge has a length longer than a length of the outer circumferential edge.

3. An inductor component comprising:

an element body having a first principal surface and a second principal surface opposite to each other;

a coil that is in the element body and is wound in a spiral shape along an axis; and

a first external electrode and a second external electrode that are on the element body and are electrically connected to the coil, wherein

the axis of the coil is parallel to the first principal surface,

the coil includes

a plurality of first coil wirings which are on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface,

a plurality of second coil wirings which are on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface,

a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and

a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis,

each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings configure at least a part of the spiral shape by being connected in this order, and

on a cross section parallel to the first principal surface and including the axis, each of the first penetration wirings has an inner circumferential edge which is parallel to the axis and faces the axis side and an outer circumferential edge which is parallel to the axis and faces a side opposite to the axis, and a length of the inner circumferential edge is longer than a length of the outer circumferential edge.

4. An inductor component comprising:

an element body having a first principal surface and a second principal surface opposite to each other;

a coil that is in the element body and is wound in a spiral shape along an axis; and

a first external electrode and a second external electrode that are on the element body and are electrically connected to the coil, wherein

the axis of the coil is parallel to the first principal surface,

the coil includes

a plurality of first coil wirings which are on the first principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the first principal surface,

a plurality of second coil wirings which are on the second principal surface side with respect to the axis and are arranged along the axis on a plane parallel to the second principal surface,

a plurality of first penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings and are arranged along the axis, and

a plurality of second penetration wirings which extend from the respective first coil wirings toward the respective second coil wirings, are on a side opposite to the respective first penetration wirings with respect to the axis, and are arranged along the axis,

each of the first coil wirings, each of the first penetration wirings, each of the second coil wirings, and each of the second penetration wirings configure at least a part of the spiral shape by being connected in this order, and

when a bisector of an angle defined by each of the first coil wirings and each of the second coil wirings connected to a reference first penetration wiring that is one of the first penetration wirings is defined when viewed in a direction orthogonal to the first principal surface, on a cross section parallel to the first principal surface and including the axis, the reference first penetration wiring has an inner circumferential edge parallel to a direction orthogonal to the bisector and facing the bisector side and an outer circumferential edge parallel to the direction orthogonal to the bisector and facing a side opposite to the bisector, and the inner circumferential edge has a length longer than a length of the outer circumferential edge.

5. The inductor component according to claim **1**, wherein the element body includes SiO_2.

6. The inductor component according to claim **1**, wherein the inner circumferential edges of the first penetration wirings have respective convex curved portions.

7. The inductor component according to claim **6**, wherein the plurality of first penetration wirings include two of the first penetration wirings in which orientations of the curved portions of the inner circumferential edges are different from each other.

8. The inductor component according to claim **1**, wherein the inner circumferential edges of the first penetration wirings have a length which is 1.5 times or more a length of the outer circumferential edges of the first penetration wirings.

9. The inductor component according to claim **1**, wherein when viewed in the direction orthogonal to the first principal surface, a first end portion of each of the first coil wirings is connected to a first end portion of each of the first penetration wirings, and an outer shape of the coil of the first end portion of each of the first coil wirings conforms to an outer shape of the coil of the first end portion of each of the first penetration wirings.

10. The inductor component according to claim **1**, wherein

when viewed in the direction orthogonal to the first principal surface, an angle defined by each of the first coil wirings and each of the second coil wirings connected to the same first penetration wiring is from 5° to 45°.

11. The inductor component according to claim **1**, wherein

on a cross section orthogonal to an extending direction of the first coil wirings, upper surfaces of the first coil wirings on a side opposite to the axis have a convex shape protruding upward on a side opposite to the axis.

12. The inductor component according to claim **11**, wherein

the first external electrode is on the first coil wirings, and

the upper surfaces of the first coil wirings face the first external electrode.

13. The inductor component according to claim **1**, wherein

when viewed in a direction parallel to the axis, the first penetration wirings and the second penetration wirings are not parallel to each other.

14. The inductor component according to claim **1**, wherein

the element body includes SiO_2, and

the first penetration wirings includes SiO_2.

15. The inductor component according to claim **1**, wherein

each of the first penetration wirings has a void portion or a resin portion.

16. The inductor component according to claim **1**, wherein

each of the first penetration wirings includes a conductive layer on an outer circumferential side when viewed in an extending direction of the first penetration wirings, and

a non-conductive layer positioned inside the conductive layer.

17. The inductor component according to claim **1**, wherein

a length of the coil in an axial direction is shorter than an inner diameter of the coil.

18. The inductor component according to claim **1**, wherein

the first penetration wirings extend in the direction orthogonal to the first principal surface, and

a cross-sectional area of at least one of both end portions of each of the first penetration wirings in the extending direction is larger than a cross-sectional area of a central portion of each of the first penetration wirings in the extending direction.

19. The inductor component according to claim **1**, wherein

when viewed in the direction orthogonal to the first principal surface, the first external electrode and the second external electrode are on an inner side with respect to an outer surface of the element body.

20. The inductor component according to claim **1**, further comprising:

an organic insulating body on the first principal surface, wherein

the element body is an inorganic insulating body, and the organic insulating body is on an inner side with respect to an outer surface of the inorganic insulating body when viewed in the direction orthogonal to the first principal surface.

* * * * *