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## INDUCTOR COMPONENT

### Abstract

An inductor component includes an element body having first and second principal surfaces opposite to each other; a coil that has at least a part in the element body and is wound in a spiral shape along an axis; and first and second external electrodes that are outside 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, and 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.

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## Background/Summary

CROSS REFERENCE TO RELATED APPLICATION [0001] This application claims benefit of priority to International Patent Application No. PCT/JP2023/030260, filed Aug. 23, 2023, and to Japanese Patent Application 2022-176445, 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 has at least a part 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 outside 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. The plurality of first coil wirings include an endmost coil wiring provided at an endmost position on one side in the axial direction. The endmost coil wiring has an upper surface positioned on a side in a first direction from the second principal surface side toward the first principal surface side, and a first side surface and a second side surface positioned on both sides sandwiching a center line of the endmost coil wiring in an extending direction thereof when viewed in a direction orthogonal to the first principal surface. The first external electrode includes a first part in contact with at least a part of the first side surface, a second part in contact with at least a part of the upper surface, and a third part in contact with at least a part of the second side surface, and the first part, the second part, and the third part are continuous in this order and form a protrusion protruding toward one side in the first direction.
[0008] According to the aspect, 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 first external electrode has the protrusion protruding toward the side in the first direction, a surface area is increased as compared with the case of a flat surface without the protrusion, and it is possible to improve the fixing strength with a connection member such as solder. In addition, the protrusion of the first external electrode is in contact with the endmost coil wiring, and the first external electrode and the endmost coil wiring are directly connected to each other. Consequently, it is possible to decrease the direct current resistance (Rdc) as compared with a case where the first external electrode and the endmost coil wiring are connected by, for example, a via wiring or the like.
[0009] Preferably, in an embodiment of the inductor component, the first external electrode has a thickness smaller than a thickness of the first coil wirings.
[0010] According to the embodiment, it is possible to decrease a thickness of the inductor component.
[0011] Preferably, in the embodiment of the inductor component, the element body contains SiO.sub.2.
[0012] According to the embodiment, it is possible to impart insulation properties and stiffness to the element body.
[0013] Preferably, in the embodiment of the inductor component, the first external electrode includes a plurality of conductive layers including a conductive layer made of a material different from a material of a conductive layer of the endmost coil wiring.
[0014] According to the embodiment, it is possible to impart, to the first external electrode, characteristics different from those of the endmost coil wiring.
[0015] Preferably, in the embodiment of the inductor component, the first external electrode further includes a bottom portion which is provided continuously from the first part of the protrusion to a side opposite to the second part and extends in a direction parallel to the first principal surface; and a wall portion which is provided continuously from the bottom portion and extends in the first direction.
[0016] According to the embodiment, it is possible to further increase the surface area of the first external electrode such that it is possible to further improve, for example, the fixing strength with the connection member such as solder.
[0017] Preferably, in the embodiment of the inductor component, the first external electrode further

includes a fourth part which is separated from the second part and is positioned closer to the side in the first direction than the second part is.
[0018] According to the embodiment, since the first external electrode further includes the fourth part positioned closer to the side in the first direction than the second part is, it is possible to further increase the surface area of the first external electrode, and it is possible to further improve, for example, the fixing strength with the connection member such as solder.
[0019] Preferably, in the embodiment of the inductor component, the first principal surface has a recess, the recess has a side surface having a stepped shape, and at least a part of the first external electrode has a shape which is in contact with the side surface and conforms to the side surface.
[0020] According to the embodiment, it is possible to further increase the surface area of the first external electrode such that it is possible to further improve, for example, the fixing strength with the connection member such as solder.
[0021] Preferably, the embodiment of the inductor component further comprises an insulating body provided on a part of the first principal surface. At least a part of the first external electrode is continuously in contact with the insulating body, the first principal surface, and the first side surface of the protrusion.
[0022] According to the embodiment, since it is possible to make the first external electrode have an uneven shape, for example, it is possible to further improve the fixing strength with the connection member such as solder.
[0023] Preferably, in the embodiment of the inductor component, the first coil wiring is provided in the first principal surface, the inductor component further comprises an insulating body that covers the first coil wiring and has a shape conforming to a shape of the first coil wiring, and at least a part of the first external electrode is in contact with the insulating body and has a shape conforming to the shape of the first coil wiring.
[0024] According to the embodiment, since at least a part of the first external electrode has a shape conforming to the shape of the first coil wirings, it is possible to further increase the surface area of the first external electrode, and it is possible to further improve, for example, the fixing strength with the connection member such as solder.
[0025] 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.
[0026] 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.
[0027] 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.
[0028] 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 increase the Q value.
[0029] Preferably, in the embodiment of the inductor component, the element body contains SiO.sub.2, and the first penetration wirings contain SiO.sub.2.
[0030] 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.
[0031] Preferably, in the embodiment of the inductor component, each of the first penetration wirings has a void portion or a resin portion.
[0032] 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.
[0033] 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.
[0034] 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.
[0035] 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.
[0036] According to the embodiment, since the coil length is short and the inner diameter of the coil is large, it is possible to increase the Q value.
[0037] 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.
[0038] 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.
[0039] Preferably, in the embodiment of the inductor component, the coil component has a thickness of 200 μm or smaller.
[0040] According to the embodiment, it is possible to decrease a thickness of the inductor component.
[0041] 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.
[0042] 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.
[0043] 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.

## Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] FIG. **1** is a schematic bottom view of an inductor component from a bottom surface side according to a first embodiment;

[0045] FIG. **2** is a cross-sectional view taken along line II-II in FIG. **1**;

[0046] FIG. **3** is a cross-sectional view taken along line III-III in FIG. **1**;

[0047] FIG. **4** is an enlarged view of portion A of FIG. **3**;

[0048] FIG. **5**A is a schematic cross-sectional view illustrating a method for manufacturing an inductor component;

[0049] FIG. **5**B is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0050] FIG. **5**C is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0051] FIG. **5**D is a schematic cross-sectional view for illustrating the method for manufacturing an inductor component;

[0052] FIG. **5**E is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0053] FIG. **5**F is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0054] FIG. **5**G is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0055] FIG. **5**H is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0056] FIG. **5**I is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0057] FIG. **5**J is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0058] FIG. **5**K is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0059] FIG. **5**L is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0060] FIG. **5**M is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0061] FIG. **5**N is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;

[0062] FIG. **5**O is a schematic cross-sectional view illustrating the method for manufacturing the inductor component;

[0063] FIG. **6**A is a cross-sectional view showing a first modification example of the inductor component;

[0064] FIG. **6**B is a cross-sectional view showing a second modification example of the inductor component;

[0065] FIG. **6**C is a cross-sectional view showing a third modification example of the inductor component;

[0066] FIG. **6**D is a cross-sectional view showing a fourth modification example of the inductor component;

[0067] FIG. **6**E is a cross-sectional view showing a fifth modification example of the inductor component;

[0068] FIG. **7** is a schematic bottom view of an inductor component from a bottom surface side

according to a second embodiment;
[0069] FIG. **8** is a cross-sectional view taken along line VIII-VIII in FIG. **7**;
[0070] FIG. **9** is an enlarged view of portion A of FIG. **8**;
[0071] FIG. **10**A is a schematic cross-sectional view illustrating a method for manufacturing an inductor component;
[0072] FIG. **10**B is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0073] FIG. **10**C is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0074] FIG. **10**D is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0075] FIG. **10**E is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0076] FIG. **10**F is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0077] FIG. **10**G is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0078] FIG. **10**H is a schematic cross-sectional view illustrating the method for manufacturing an inductor component;
[0079] FIG. **11**A is a schematic cross-sectional view showing a first modification example of the inductor component;
[0080] FIG. **11**B is a schematic cross-sectional view showing a second modification example of the inductor component; and
[0081] FIG. **11**C is a schematic cross-sectional view showing a third modification example of the inductor component.

## DETAILED DESCRIPTION

[0082] 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

[0083] 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**. FIG. **4** is an enlarged view of portion A of FIG. **3**. 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

[0084] 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** to **4**, the inductor component **1** includes the element body **10**, a coil **110** that has at least a part 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 outside the element body **10** and are electrically connected to the coil **110**.
[0085] 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.

[0086] As shown in the drawings, hereinafter, for convenience of description, the length direction (longitudinal direction) of the element body **10** is defined as an X direction. A direction from the first end surface **100***e***1** toward the second end surface **100***e***2** is defined as a forward X direction, and a direction opposite to the forward X direction is defined as a reverse X direction. In addition, a width direction of the element body **10** is defined as a Y direction. A direction from the first side surface **100***s***1** toward the second side surface **100***s***2** is defined as a forward Y direction, and a direction opposite to the forward Y direction is defined as a reverse Y direction. In addition, a height direction of the element body **10** is defined as a Z direction. A direction from the bottom surface **100***b* toward the top surface **100***t* is defined as a forward Z direction, and a direction opposite to the forward Z direction is defined as a reverse 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. In this specification, a direction from the top surface **100***t* side toward the bottom surface **100***b* side is referred to as a first direction D**1**. The first direction D**1** includes not only a direction parallel to the Z direction but also a direction inclined from a direction parallel to the Z direction. In this embodiment, the first direction D**1** is the reverse Z direction.

[0087] 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.

[0088] 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. The plurality of bottom surface wirings **11***b* include an endmost coil wiring **11***e* positioned on one side in the axis AX direction. In this embodiment, of the plurality of bottom surface wirings **11***b*, both the two bottom surface wirings **11***b* positioned at both ends in the axis AX direction are the endmost coil wirings **11***e*. 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.

[0089] 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.

[0090] 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.

[0091] 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.

[0092] 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.

[0093] As shown in FIGS. **1** and **4**, the endmost coil wiring **11***e* positioned on the first end surface **100***e***1** side with respect to the center of the element body **10** in the X direction has an upper surface u positioned on a side in the first direction D**1**, and a first side surface S**1** and a second side surface S**2** positioned on both sides sandwiching a center line CL of the endmost coil wiring **11***e* in an extending direction thereof when viewed in a direction (Z direction) orthogonal to the bottom surface **100***b*. The first external electrode **121** includes a first part P**1** in contact with at least a part of the first side surface S**1** of the endmost coil wiring **11***e*, a second part P**2** in contact with at least a part of the upper surface u of the endmost coil wiring **11***e*, and a third part P**3** in contact with at least a part of the second side surface S**2** of the endmost coil wiring **11***e*. The first part P**1**, the second part P**2**, and the third part P**3** are continuous in this order and form a protrusion P protruding toward the side in the first direction D**1**.

[0094] Similarly, the endmost coil wiring **11***e* positioned on the second end surface **100***e***2** side with respect to the center of the element body **10** in the X direction has an upper surface u positioned on a side in the first direction D**1**, and a first side surface S**1** and a second side surface S**2** positioned on both sides sandwiching a center line CL of the endmost coil wiring **11***e* in an extending direction thereof when viewed in the direction (Z direction) orthogonal to the bottom surface **100***b*. The second external electrode **122** includes a first part in contact with at least a part of the first side surface S**1** of the endmost coil wiring **11***e*, a second part in contact with at least a part of the upper surface u of the endmost coil wiring **11***e*, and a third part in contact with at least a part of the second side surface S**2** of the endmost coil wiring **11***e*. The first part, the second part, and the third part are continuous in this order and form a protrusion P protruding toward the side in the first direction D**1**.

[0095] According to the configuration described above, since the first external electrode **121** and the second external electrode **122** have the respective protrusions P protruding toward the side in the first direction D**1**, a surface area is increased as compared with the case of a flat surface without the protrusion P, and it is possible to improve the fixing strength with a connection member such as solder. In addition, the protrusions P of the first external electrode **121** and the second external electrode **122** are in contact with the respective endmost coil wirings **11***e*, and both the first external electrode **121** and the second external electrode **122** and the respective endmost coil wirings **11***e* are directly connected to each other. Consequently, it is possible to decrease the direct current resistance (Rdc) as compared with a case where both the first external electrode **121** and the second external electrode **122** and the endmost coil wirings **11***e* are connected by, for example, via wirings or the like, respectively.

2. Configurations of Respective Units

(Inductor Component **1**)

[0096] A volume of the inductor component **1** is preferably 0.08 mm.sup.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 200 μm or smaller. This enables a thin inductor component **1** to be obtained.

[0097] 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**)

[0098] Preferably, the element body **10** contains SiO.sub.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.

[0099] 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.

[0100] 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.

[0101] As shown in FIG. **4**, the bottom surface **100***b* of the element body **10** has a recess C. To be more specific, the recess C is provided such that a connection part of each of the two endmost coil wirings **11***e* with the first external electrode **121** or the second external electrode **122** is exposed from the element body **10**. A shape of the recess C when viewed in the Z direction is not particularly limited as long as the connection part is exposed from the element body **10**, but in this embodiment, the recess C is formed in a rectangular shape.

(Coil **110**)

[0102] 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.

[0103] 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**.

[0104] 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.

[0105] 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.

[0106] As described above, the plurality of bottom surface wirings **11***b* include the endmost coil wiring **11***e* provided at an endmost position on one side in the axis AX direction. In this embodiment, an end portion (in other words, the connection part with the first external electrode **121** or the second external electrode **122**.) of the endmost coil wiring **11***e* on one side in the extending direction is disposed in the recess C provided in the bottom surface **100***b* of the element body **10** and is exposed from the element body **10**. To be more specific, of both end portions of the endmost coil wiring **11***e* in the extending direction, an end portion on one side on which the endmost coil wiring is connected to the first external electrode **121** or the second external electrode **122** is disposed in the recess C and is exposed from the element body **10**. Note that the entire endmost coil wiring **11***e* may be disposed in the recess C and exposed from the element body **10**. In this case, the first external electrode **121** or the second external electrode **122** is preferably in contact with an entire exposed surface of the endmost coil wiring **11***e* (in other words, the entire first side surface s**1**, the entire second side surface s**2**, and the entire upper surface u).

[0107] 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.

[0108] 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).

[0109] 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.

[0110] Preferably, the first penetration wirings **13** contain SiO.sub.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.sub.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.sub.2.

[0111] 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.

[0112] Preferably, at least one wiring of the bottom surface wirings **11***b* and the top surface wirings **11***t* contains SiO.sub.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.sub.2, thus enabling cracks between the wiring and the element body **10** to be reduced.

(External Electrodes **121** and **122**)

[0113] 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**. As in this embodiment, in a case where the recess C is provided in the bottom surface **100***b* of the element body **10**, the outer surface **100** of the element body **10** includes inner surfaces of the recess C. In addition, in this specification, in the case of using the term "outside the element body", "outside" includes a region on an inner side of the recess C. That is, the region on the inner side of the recess C is included in the outside of the element body **10**.

[0114] 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**.

[0115] The first external electrode **121** has abase 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 Cu, Ni, Ti, or a combination thereof. The plating layer **121***e***2** contains, for example, a conductive material such as Ni or Au. 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.

[0116] The first external electrode **121** is provided to cover the entire recess C provided in the bottom surface **100***b* of the element body **10** when viewed in the Z direction. Consequently, the first external electrode **121** is in contact with an entire surface as a part of the first side surface S**1** of the endmost coil wiring **11***e* which is exposed from the element body **10**, is in contact with an entire surface as a part of the upper surface u of the endmost coil wiring **11***e* which is exposed from the element body **10**, and is in contact with an entire surface as a part the second side surface S**2** of the endmost coil wiring **11***e* which is exposed from the element body **10**. As a result, the first external electrode **121** has the protrusion P at a position corresponding to the part of the endmost coil wiring **11***e* which is exposed from the element body **10**. The first external electrode **121** has a step **121***s* corresponding to a step (a first surface to be described below) of the recess C.

[0117] Similarly, the second external electrode **122** is provided to cover the entire recess C provided in the bottom surface **100***b* of the element body **10** when viewed in the Z direction. Consequently, the second external electrode **122** is in contact with an entire surface as a part of the first side surface S**1** of the endmost coil wiring **11***e* which is exposed from the element body **10**, is in contact with an entire surface as a part of the upper surface u of the endmost coil wiring **11***e* which is exposed from the element body **10**, and is in contact with an entire surface as a part the second side surface S**2** of the endmost coil wiring **11***e* which is exposed from the element body **10**. As a result, the second external electrode **122** has the protrusion P at a position corresponding to the part of the endmost coil wiring **11***e* which is exposed from the element body **10**. The second external electrode **122** has a step **122***s* corresponding to a step of the recess C.

(Other Preferred Configurations)

[0118] Preferably, as shown in FIG. **4**, a thickness t**1** of the first external electrode **121** in the Z direction is smaller than a thickness t**2** of the bottom surface wiring **11***b* in the Z direction. Here, in a case where the first external electrode **121** includes a plurality of layers, the thickness of the first external electrode **121** indicates thicknesses of all the layers Even when the thickness of the first external electrode **121** is decreased, the DC resistance (Rdc) is not significantly affected. Therefore, according to the configuration described above, it is possible to decrease the thickness of the inductor component **1** while reducing an increase in the DC resistance. More preferably, the thickness t**1** of the first external electrode **121** is ½ or less of the thickness t**2** of the bottom surface wiring **11***b*. Consequently, it is possible to more effectively decrease the thickness of the inductor component **1**. Similarly, the thickness of the second external electrode **122** may also be smaller than the thickness of the bottom surface wiring **11***b*.

[0119] Preferably, the first external electrode **121** includes a plurality of conductive layers including a conductive layer made of a material different from a material of a conductive layer of the endmost coil wiring **11***e*. To be more specific, for example, a conductive layer made of a material having high conductivity such as Cu or Ag may be employed in the endmost coil wiring **11***e*. In the first external electrode **121**, for example, a conductive layer which is made of Ti or the like and has good adhesion with the endmost coil wiring **11***e*, a conductive layer made of Ni or the like having high electromigration resistance, a conductive layer made of Au or the like having high corrosion resistance, a conductive layer having high solder wettability, or the like may be employed. According to the configuration described above, it is possible to impart, to the first external electrode **121**, characteristics different from those of the endmost coil wiring **11***e*. Similarly, the second external electrode **122** may include a plurality of conductive layers including a conductive layer made of a material different from a material of a conductive layer of the endmost coil wiring **11***e*.

[0120] Preferably, the first external electrode **121** further includes a bottom portion BP**1** which is provided continuously from the first part P**1** of the protrusion P to a side opposite to the second part P**2** and extends in a direction (Y direction) parallel to the bottom surface **100***b*, and a wall portion WP**1** which is provided continuously from the bottom portion BP**1** and extends in the first direction D**1**. According to this configuration, it is possible to further increase the surface area of the first external electrode **121** such that it is possible to further improve, for example, the fixing strength with the connection member such as solder. In addition, preferably, the first external electrode **121** further includes a bottom portion BP**2** which is provided continuously from the third part P**3** of the protrusion P to the side opposite to the second part P**2** and extends in the direction parallel to the bottom surface **100***b*, and a wall portion WP**2** which is provided continuously from the bottom portion BP**2** and extends in the first direction D**1**. According to this configuration, it is possible to further increase the surface area of the first external electrode **121** such that it is possible to further improve, for example, the fixing strength with the connection member such as solder. Similarly, the second external electrode **122** may further include a bottom portion which is provided continuously from at least one of the first part and the third part of the protrusion P to the side opposite to the second part and extends in the direction parallel to the bottom surface **100***b*, and a wall portion which is provided continuously from the bottom portion and extends in the first direction D**1**.

[0121] Preferably, the first external electrode **121** further includes a fourth part P**4** which is separated from the second part P**2** and is positioned on a side in the first direction D**1** from the second part P**2**. To be more specific, the fourth part P**4** is a part of the first external electrode **121** provided on the bottom surface **100***b* excluding the recess C. According to this configuration, since the first external electrode **121** further includes the fourth part P**4**, it is possible to further increase the surface area of the first external electrode **121**. In addition, since the fourth part P**4** is further included, a shape of the first external electrode **121** between the second part P**2** and the fourth part P**4** can be a recessed shape. Further, since the fourth part P**4** is positioned closer to the side in the first direction D**1** side than the second part P**2** is, a depth of the recessed shape can be deeper than that in a case where the fourth part P**4** is positioned closer to an opposite side in the first direction D**1** (a side in the forward Z direction) than the second part P**2** is. As a result, it is possible to more effectively increase the surface area of the first external electrode **121** such that it is possible to further improve, for example, the fixing strength with the connection member such as solder. Similarly, the second external electrode **122** may further include a fourth part which is separated from the second part and is positioned on a side in the first direction D**1** from the second portion.

[0122] Preferably, the bottom surface **100***b* has the recess C, the recess C has a side surface CS having a stepped shape, and at least a part of the first external electrode **121** has a shape which is in contact with the side surface CS and conforms to the side surface CS. To be more specific, the side surface CS has a first surface f**1** extending in the Z direction, a second surface f**2** extending in the Z direction, and a third surface f**3** that connects the first surface f**1** and the second surface f**2** to each other and extends along an XYplane. The first surface f**1** is disposed on an opening side of the recess C, and the second surface f**2** is disposed on the bottom surface side of the recess C. A width of the first surface f**1** in the Y direction is larger than a width of the second surface f**2** in the Y direction. A width of the first surface f**1** in the X direction is larger than a width of the second surface f**2** in the X direction. The first surface f**1**, the second surface f**2**, and the third surface f**3** form a stepped shape of the side surface CS. The number of steps of the stepped shape is not particularly limited. According to the configuration described above, it is possible to further increase the surface area of the first external electrode **121** such that it is possible to further improve, for example, the fixing strength with the connection member such as solder. Similarly, at least a part of the second external electrode **122** may be in contact with the side surface having the stepped shape of the recess C and have a shape conforming to the side surface.

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

[0123] Next, a method for manufacturing the inductor component **1** will be described with reference to FIGS. **5**A to **5**O. FIGS. **5**A to **5**G, **5**I, **5**K, and **5**M are views corresponding to a cross section taken along line II-II in FIG. **1**. FIGS. **5**H, **5**J, **5**L, **5**N, and **5**O are views corresponding to a cross section taken along line III-III in FIG. **1**.

[0124] As shown in FIG. **5**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.

[0125] As shown in FIG. **5**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.

[0126] As shown in FIG. **5**C, atop 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.

[0127] As shown in FIG. **5**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. **5**B.

[0128] As shown in FIG. **5**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. **5**C.

[0129] By repeating the above-described processes, as shown in FIG. **5**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**.

[0130] As shown in FIG. **5**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*. FIG. **5**H shows the same step as that in FIG. **5**G. As shown in FIG. **5**H, a groove **1016***a* is provided in the sixth insulating layer **1016**, and the bottom surface conductor layer **1011***b* is provided in the groove **1016***a*. The groove **1016***a* is a part of the recess C.

[0131] As shown in FIG. **5**I, a seventh insulating layer **1017** is provided on the sixth insulating layer **1016**. Subsequently, a groove is provided in the seventh insulating layer **1017** so that at least a part of the bottom surface conductor layer **1011***b* connected to the first and second external electrodes is exposed. FIG. **5**J shows the same step as that in FIG. **5**I. As shown in FIG. **5**J, a groove **1017***a* is provided in the seventh insulating layer **1017**. The groove **1017***a* is a part of the recess C. In this embodiment, a size of an opening of the groove **1017***a* is larger than a size of an opening of the groove **1016***a*. Consequently, it is possible to form the side surface of the recess C into the stepped shape.

[0132] As shown in FIG. **5**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**. 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. FIG. **5**L shows the same step as that in FIG. **5**K. As shown in FIG. **5**L, the element body **10** in which the recess C is provided in the bottom surface **100***b* is formed by the sintering.
[0133] As shown in FIG. **5**M, for example, a conductive material such as Cu, Ni, Ti, or a combination thereof is deposited by a sputtering method, and etched into a predetermined shape by a photolithography method, and the base layer **121***e***1** is formed. The predetermined shape is a shape to allow the base layer **121***e***1** to cover at least an inner surface of the recess C. Subsequently, the plating layer **121***e***2** is formed by electroless plating to cover the base layer **121***e***1**. The plating layer **121***e***2** is, for example, Ni/Au. In this manner, the external electrodes **121** and **122** are formed. FIG. **5**N shows the same step as that in FIG. **5**M. As shown in FIG. **5**N, the first external electrode **121** is in contact with the exposed part of the endmost coil wiring **11***e* from the element body **10**, and the protrusion P is formed on the first external electrode **121**. Although not shown, the second external electrode **122** is in contact with the exposed part of the endmost coil wiring **11***e* from the element body **10**, and the protrusion P is formed on the second external electrode **122**.
[0134] As shown in FIG. **5**O, division into individual components is performed along a cutting line D. Consequently, as shown in FIG. **3**, the inductor component **1** is manufactured.

## 3. Modification Examples

### First Modification Example

[0135] FIG. **6**A is a view showing a first modification example of the inductor component, and the view corresponds to the cross section taken along line III-III in FIG. **1**. As shown in FIG. **6**A, in an inductor component **1**A of the first modification example, the element body **10** is not provided in a region on a side in the forward Y direction and a region on a side in the reverse Y direction with respect to the part of the endmost coil wiring **11***e* exposed from the element body **10**. This enables the first external electrode **121** to be easily brought in contact with the bottom surface **100***b* of the element body **10**.

### Second Modification Example

[0136] FIG. **6**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. **6**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.
[0137] 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.

Third Modification Example

[0138] FIG. **6**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. **6**C, in an inductor component **1**C of the third 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.

[0139] 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.

Fourth Modification Example

[0140] FIG. **6**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. **6**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. **6**B.

[0141] 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.

[0142] 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 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.

[0143] 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.

[0144] 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 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.

Fifth Modification Example

[0145] FIG. **6**E is a view showing a fifth 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. **6**E, an inductor component **1**E of the fifth modification example includes a first coil **110**A and a second coil **110**B as compared with the inductor component **1**C of the third modification example shown in FIG. **6**C.

[0146] 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.

[0147] 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**C of the third 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.

[0148] 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.

[0149] 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**C of the third 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

[0150] FIG. **7** is a schematic bottom view of a second embodiment of the inductor component from the bottom surface side. FIG. **8** is a cross-sectional view taken along line VIII-VIII in FIG. **7**. FIG. **9** is an enlarged view of portion A of FIG. **8**. In FIG. **7**, for convenience, an insulating layer is omitted, and the external electrodes are drawn by two-dot chain lines. In addition, in FIG. **7**, 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, providing of an insulating body, and a configuration of the external electrode, and these different configurations will be 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**F)

[0151] As shown in FIG. **7**, in an inductor component **1**F, 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.
[0152] A length of the coil **110** in the axis AX direction is shorter than an inner diameter of the coil **110**. 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**)
[0153] 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.
[0154] 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.
[0155] 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.sub.2), and in this case, cerium oxide serves as a sensitizer, and processing by photolithography becomes easier.
[0156] 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.
(Coil **110**)
[0157] As shown in FIG. **7**, 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 plurality of bottom surface wirings **11***b* include an endmost coil wiring **11***e* positioned on one side in the axis AX direction (Y direction). In this embodiment, of the plurality of bottom surface wirings **11***b*, both the two bottom surface wirings **11***b* positioned at both ends in the axis AX direction are the endmost coil wirings **11***e*. 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.
[0158] 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.

(Insulating Body **22**)

[0159] As shown in FIG. **8**, the inductor component **1**F 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*.

[0160] 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.

[0161] The insulating body **22** covering the bottom surface **100***b* has an opening **22***a* so that the connection part of the endmost coil wiring **11***e* which is connected to the external electrode **121** or **122** is exposed. The opening **22***a* is a through-hole penetrating the insulating body **22** in a thickness direction (Z direction) thereof. A shape of the opening **22***a* when viewed in the Z direction is not particularly limited as long as the connection part of the bottom surface wiring **11***b* is exposed. In this embodiment, as shown in FIG. **7**, the shape of the opening **22***a* is sufficiently larger than a shape of the connection part of the bottom surface wiring **11***b* when viewed in the Z direction, and is similar to the shape of the connection part.

[0162] To be more specific, when viewed in the Z direction, in the endmost coil wiring **11***e* positioned on the second side surface **100***s***2** side with respect to the center of the element body **10**, the shape of the connection part (in other words, the part of the endmost coil wiring **11***e* which is exposed from the insulating body **22**) connected to the first external electrode **121** is a cannonball shape with a tip portion having a width in the Y direction, and the width becomes narrower toward the side in the reverse X direction. When viewed in the Z direction, the shape of the opening **22***a* provided on the first external electrode **121** side is sufficiently larger than the shape of the connection part, and is formed into a cannonball shape with a tip portion having a width in the Y direction, and the width becomes narrower toward the side in the reverse X direction so that the shape of the opening becomes similar to the shape of the connection part.

[0163] Similarly, when viewed in the Z direction, in the endmost coil wiring **11***e* positioned on the first side surface **100***s***1** side with respect to the center of the element body **10**, the shape of the connection part (in other words, the part of the endmost coil wiring **11***e* which is exposed from the insulating body **22**) connected to the second external electrode **122** is a cannonball shape with a tip portion having a width in the Y direction, and the width becomes narrower toward the side in the forward X direction. When viewed in the Z direction, the shape of the opening **22***a* provided on the second external electrode **122** side is sufficiently larger than the shape of the connection part, and is formed into a cannonball shape with a tip portion having a width in the Y direction, and the width becomes narrower toward the side in the forward X direction so that the shape of the opening becomes similar to the shape of the connection part. The shape of the opening **22***a* is sufficiently larger than the shape of the connection part, thereby enabling the connection part to be more reliably exposed from the insulating body **22**, and the shape of the opening **22***a* is similar to the shape of the connection part, thereby enabling an etching amount of the insulating body **22** to be minimized so that insulation properties of the wiring can be ensured.

(External Electrodes **121** and **122**)

[0164] As shown in FIGS. **7**, **8**, and **9**, the first external electrode **121** is provided to cover the entire opening **22***a* positioned on the first end surface **100***e***1** side when viewed in the Z direction. Consequently, the first external electrode **121** has a first part P**1** in contact with at least a part of the first side surface S**1** of the endmost coil wiring **11***e*, a second part P**2** in contact with at least a part of the upper surface u of the endmost coil wiring **11***e*, and a third part P**3** in contact with at least a part of the second side surface S**2** of the endmost coil wiring **11***e*, and the first part P**1**, the second part P**2**, and the third part P**3** are continuous in this order and form the protrusion P protruding toward the side in the first direction D**1**. To be more specific, the first external electrode **121** is in contact with an entire surface as a part of the first side surface S**1** of the endmost coil wiring **11***e* which is exposed from the insulating body **22**, is in contact with an entire surface as a part of the upper surface u of the endmost coil wiring **11***e* which is exposed from the element body **10**, and is in contact with an entire surface as a part of the second side surface S**2** of the endmost coil wiring **11***e* which is exposed from the element body **10**. As a result, the first external electrode **121** has the protrusion P at a position corresponding to the part of the endmost coil wiring **11***e* which is exposed from the element body **10**.

[0165] Similarly, the second external electrode **122** is provided to cover the entire opening **22***a* positioned on the second end surface **100***e***2** side when viewed in the Z direction. Consequently, the second external electrode **122** has a first part in contact with at least a part of the first side surface S**1** of the endmost coil wiring **11***e*, a second part in contact with at least a part of the upper surface u of the endmost coil wiring **11***e*, and a third part in contact with at least a part of the second side surface S**2** of the endmost coil wiring **11***e*, and the first part, the second part, and the third part are continuous in this order and form the protrusion P protruding toward the side in the first direction D**1**. To be more specific, the second external electrode **122** is in contact with an entire surface as a part of the first side surface S**1** of the endmost coil wiring **11***e* which is exposed from the insulating body **22**, is in contact with an entire surface as a part of the upper surface u of the endmost coil wiring **11***e* which is exposed from the element body **10**, and is in contact with an entire surface as a part of the second side surface S**2** of the endmost coil wiring **11***e* which is exposed from the element body **10**. As a result, the second external electrode **122** has the protrusion P at a position corresponding to the part of the endmost coil wiring **11***e* which is exposed from the element body **10**.

[0166] Preferably, when viewed in the direction (Z 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**. According to this configuration, 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 **1**F is performed. Therefore, even if the inductor component **1**F 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.

[0167] According to the inductor component **1**F, since the first external electrode **121** and the second external electrode **122** have the respective protrusions P protruding toward the side in the first direction D**1**, a surface area is increased as compared with the case of a flat surface without the protrusion P, and it is possible to improve the fixing strength with a connection member such as solder. In addition, since the protrusions P of the first external electrode **121** and the second external electrode **122** are in contact with the respective endmost coil wirings **11***e*, it is possible to directly connect both the first external electrode **121** and the second external electrode **122** and the respective endmost coil wirings **11***e* are directly to each other. Consequently, it is possible to decrease the direct current resistance (Rdc) as compared with a case where both the first external electrode **121** and the second external electrode **122** and the endmost coil wirings **11***e* are connected by, for example, via wirings or the like, respectively.

[0168] Preferably, as shown in FIG. **9**, the insulating body **22** is further provided on a part of the bottom surface **100***b*, and at least a part of the first external electrode **121** is continuously provided in contact with the insulating body **22**, the bottom surface **100***b*, and the first side surface S**1** of the protrusion P. To be more specific, the first external electrode **121** includes a bottom portion BP**1** which is provided continuously from the first part P**1** of the protrusion P to the side opposite to the second part P**2** and extends in the direction parallel to the bottom surface **100***b*, and a wall portion WP**1** which is provided continuously from the bottom portion BP**1** and extends in the first direction D**1**. The wall portion WP**1**, the bottom portion BP**1**, and the first part P**1** are continuously provided in contact with the insulating body **22**, the bottom surface **100***b*, and the first side surface S**1** of the protrusion P.

[0169] In addition, in this embodiment, at least a part of the first external electrode **121** is continuously provided in contact with the insulating body **22**, the bottom surface **100***b*, and the second side surface S**2** of the protrusion P. To be more specific, the first external electrode **121** includes a bottom portion BP**2** which is provided continuously from the third part P**3** of the protrusion P to the side opposite to the second part P**2** and extends in the direction parallel to the bottom surface **100***b*, and a wall portion WP**2** which is provided continuously from the bottom portion BP**2** and extends in the first direction D**1**. The wall portion WP**2**, the bottom portion BP**2**, and the third part P**3** are provided continuously in contact with the insulating body **22**, the bottom surface **100***b*, and the second side surface S**2** of the protrusion P.

[0170] According to the configuration described above, since at least a part of the first external electrode **121** is continuously provided in contact with the insulating body **22**, the bottom surface **100***b*, and the first side surface S**1** of the protrusion P, the first external electrode **121** is formed into an uneven shape. Therefore, it is possible to further improve the fixing strength with the connection member such as solder. In addition, since at least a part of the first external electrode **121** is continuously provided in contact with the insulating body **22**, the bottom surface **100***b*, and the second side surface S**2** of the protrusion P, the first external electrode **121** is formed into an uneven shape. Therefore, it is possible to further improve the fixing strength with the connection member such as solder.

[0171] Similarly, at least a part of the second external electrode **122** may be continuously provided in contact with the insulating body **22**, the bottom surface **100***b*, and the first side surface S**1** of the protrusion P.

[0172] Preferably, the first external electrode **121** further includes a fourth part P**4** which is separated from the second part P**2** and is positioned on a side in the first direction D**1** from the second part P**2**. To be more specific, the fourth part P**4** is a part of the first external electrode **121** provided on the upper surface **22***u* of the insulating body **22**. According to this configuration, since the first external electrode **121** further includes the fourth part P**4**, it is possible to further increase the surface area of the first external electrode **121**. Similarly, the second external electrode **122** may further include a fourth part which is separated from the second part and is positioned on a side in the first direction D**1** from the second portion.

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

[0173] Next, a method for manufacturing the inductor component **1**F will be described with reference to FIGS. **10**A to **10**H. FIGS. **10**A to **10**H are views corresponding to a cross section taken along line VIII-VIII in FIG. **7**.

[0174] As shown in FIG. **10**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.

[0175] As shown in FIG. **10**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.

[0176] As shown in FIG. **10**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.

[0177] As shown in FIG. **10**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.

[0178] As shown in FIG. **10**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.

[0179] As shown in FIG. **10**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. At this time, a part of the bottom surface conductor layer **2011***b* which is the connection part connected to the first or second external electrode is exposed from the insulating layer **2022**. The hole **2022***a* becomes the opening **22***a*.

[0180] As shown in FIG. **10**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*. In addition, the first external electrode conductor layer **2121** is in contact with the bottom surface conductor layer **2011***b* via the hole **2022***a* and forms the protrusion P. 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.

[0181] As shown in FIG. **10**H, division into individual components is performed along a cutting line D. Consequently, as shown in FIG. **8**, the inductor component **1**F is manufactured.

2. Modification Examples

First Modification Example

[0182] FIG. **11**A is a view showing a first modification example of the inductor component, and the view corresponds to a cross section taken along line VIII-VIII in FIG. **7**. As shown in FIG. **11**A, in an inductor component **1**G of the first 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*.

[0183] 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.

[0184] 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**.

[0185] In addition, in the inductor component **1**G of the first modification example, the bottom surface wiring **11***b* further includes the insulating body **22** that is provided on the bottom surface **100***b*, covers the bottom surface wiring **11***b*, and has a shape conforming to the shape of the bottom surface wiring **11***b*, and at least a part of the first external electrode **121** is in contact with the insulating body **22** and has a shape conforming to the shape of the bottom surface wiring **11***b*. To be more specific, the insulating body **22** covers the bottom surface wiring **11***b*, has a shape extending in the X direction when viewed in the Z direction, and has a shape conforming to the shape of the bottom surface wiring **11***b*. In short, the insulating body **22** is provided to separately cover the individual bottom surface wirings **11***b*. In a region between the adjacent bottom surface wirings **11***b*, the bottom surface **100***b* is exposed from the insulating body **22**. A part of the first external electrode **121** excluding the protrusion P and the part thereof in contact with the bottom surface **100***b* is in contact with the insulating body **22**, has a shape extending in the X direction when viewed in the Z direction, and has a shape conforming to the shape of the bottom surface wiring **11***b*.

[0186] In addition, the insulating body **22** covers the top surface wiring **11***t*, has a shape slightly inclined in the Y direction and extending in the X direction when viewed in the Z direction, and has a shape conforming to the shape of the top surface wiring **11***t*. In short, the insulating body **22** is provided to separately cover the individual top surface wirings **11***t*. Consequently, it is possible to decrease material costs of the insulating body **22**.

[0187] Examples of a method of forming the insulating body **22** having a shape conforming to the shape of the bottom surface wiring **11***b* or the top surface wiring **11***t* include a method of forming an organic resin or inorganic insulating body on the surface of the bottom surface wiring **11***b* or the top surface wiring **11***t* by using a method such as chemical vapor deposition (CVD), sputtering, or coating.

[0188] According to the configuration described above, since at least a part of the first external electrode **121** has a shape conforming to the shape of the bottom surface wiring **11***b*, it is possible to further increase the surface area of the first external electrode **121** such that it is possible to further improve the fixing strength with the connection member such as solder.

[0189] Similarly, at least a part of the second external electrode **122** may be in contact with the insulating body **22** and have a shape conforming to the shape of the bottom surface wiring **11***b*.

Second Modification Example

[0190] FIG. **11**B is a view showing a second modification example of the inductor component, and the view corresponds to a cross section taken along line VIII-VIII in FIG. **7**. As shown in FIG. **11**B, in an inductor component **1**H of the second modification example, as compared with the inductor component **1**G of the first modification example, the insulating body **22** is further provided on the entire surface of a part of the bottom surface **100***b* excluding an outer circumferential part thereof and the part where the bottom surface wiring **11***b* is provided. A thickness of the insulating body **22** in the Z direction is smaller than a thickness of the bottom surface wiring **11***b* in the Z direction. According to this configuration, since an area of a part of the first external electrode **121** which is in opposite to the bottom surface wiring **11***b* is smaller than that in the first modification example, it is possible to decrease stray capacitance that can be generated between the first external electrode **121** and the bottom surface wiring **11***b* as compared with the first modification example. In addition, since the insulating body **22** fills a space between the adjacent bottom surface wirings **11***b* as compared with the first modification example, it is possible to ensure insulation properties between the adjacent bottom surface wirings **11***b* as compared with the first modification example.

[0191] In addition, in the inductor component **1**H of the second modification example, 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 the individual inductor components **1**H is performed.

[0192] In addition, in the inductor component **1**H of the second modification example, as compared with the inductor component **1**G of the first modification example, the insulating body **22** is further provided on the entire surface of a region of the top surface **100***t* excluding an outer circumferential part thereof and the part where the top surface wiring **11***t* is provided. A thickness of the insulating body **22** in the Z direction is smaller than a thickness of the top surface wiring **11***t* in the Z direction. Consequently, it is possible to protect the element body **10** from an external environment.

Third Modification Example

[0193] FIG. **11**C is a schematic cross-sectional view of the first penetration wiring showing a third modification example of the inductor component. As shown in FIG. **11**C, in 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.

[0194] An example of a method of forming the conductive 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**.

[0195] 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.

[0196] 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 and second embodiments may be variously combined.

[0197] In the embodiments, both the first external electrode and the second external electrode have the protrusion, but only one of the first external electrode and the second external electrode may have the protrusion. In this case, the external electrode without having the protrusion may be connected to the bottom surface wiring via a via wiring or the like provided in the element body, for example.

[0198] The present disclosure includes the following aspects.

[0199] <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 has at least a part 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 outside 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. The plurality of first coil wirings include an endmost coil wiring provided at an endmost position on one side in the axial direction. The endmost coil wiring has an upper surface positioned on a side in a first direction from the second principal surface side toward the first principal surface side, and a first side surface and a second side surface positioned on both sides sandwiching a center line of the endmost coil wiring in an extending

direction thereof when viewed in a direction orthogonal to the first principal surface. Also, the first external electrode includes a first part in contact with at least a part of the first side surface, a second part in contact with at least a part of the upper surface, and a third part in contact with at least a part of the second side surface, and the first part, the second part, and the third part are continuous in this order and form a protrusion protruding toward one side in the first direction.
[0200] <2> The inductor component according to <1>, in which the first external electrode has a thickness smaller than a thickness of the first coil wirings.
[0201] <3> The inductor component according to <1> or <2>, in which the element body contains SiO.sub.2.
[0202] <4> The inductor component according to any one of <1> to <3>, in which the first external electrode includes a plurality of conductive layers including a conductive layer made of a material different from a material of a conductive layer of the endmost coil wiring.
[0203] <5> The inductor component according to any one of <1> to <4>, in which the first external electrode further includes a bottom portion which is provided continuously from the first part of the protrusion to a side opposite to the second part and extends in a direction parallel to the first principal surface; and a wall portion which is provided continuously from the bottom portion and extends in the first direction.
[0204] <6> The inductor component according to any one of <1> to <5>, in which the first external electrode further includes a fourth part which is separated from the second part and is positioned closer to the side in the first direction than the second part is.
[0205] <7> The inductor component according to any one of <1> to <6>, in which the first principal surface has a recess, the recess has a side surface having a stepped shape, and at least a part of the first external electrode has a shape which is in contact with the side surface and conforms to the side surface.
[0206] <8> The inductor component according to any one of <1> to <7>, further including an insulating body provided on a part of the first principal surface, in which at least a part of the first external electrode is continuously in contact with the insulating body, the first principal surface, and the first side surface of the protrusion.
[0207] <9> The inductor component according to any one of <1> to <8>, in which the first coil wiring is provided in the first principal surface, the inductor component further includes an insulating body that covers the first coil wiring and has a shape conforming to a shape of the first coil wiring, and at least a part of the first external electrode is in contact with the insulating body and has a shape conforming to the shape of the first coil wiring.
[0208] <10> The inductor component according to any one of <1> to <9>, 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.
[0209] <11> The inductor component according to any one of <1> to <10>, 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.
[0210] <12> The inductor component according to any one of <1> to <11>, in which the element body contains SiO.sub.2, and the first penetration wirings contain SiO.sub.2.
[0211] <13> The inductor component according to any one of <1> to <12>, in which each of the first penetration wirings has a void portion or a resin portion.
[0212] <14> The inductor component according to any one of <1> to <13>, 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.
[0213] <15> The inductor component according to any one of <1> to <14>, in which a length of

the coil in an axial direction is shorter than an inner diameter of the coil.
[0214] <16> The inductor component according to any one of <1> to <15>, 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.
[0215] <17> The inductor component according to any one of <1> to <16>, in which the inductor component has a thickness of 200 μm or smaller.
[0216] <18> The inductor component according to any one of <1> to <17>, 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.

## Claims

**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 has at least a part 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 outside 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, the plurality of first coil wirings include an endmost coil wiring at an endmost position on one side in the axial direction, the endmost coil wiring has an upper surface on a side in a first direction from the second principal surface side toward the first principal surface side, and a first side surface and a second side surface on both sides sandwiching a center line of the endmost coil wiring in an extending direction thereof when viewed in a direction orthogonal to the first principal surface, and the first external electrode includes a first part in contact with at least a part of the first side surface, a second part in contact with at least a part of the upper surface, and a third part in contact with at least a part of the second side surface, and the first part, the second part, and the third part are continuous in this order and configure a protrusion protruding toward one side in the first direction.
**2**. The inductor component according to claim 1 wherein the first external electrode has a thickness smaller than a thickness of the first coil wirings.
**3**. The inductor component according to claim 1, wherein the element body includes SiO.sub.2.
**4**. The inductor component according to claim 1, wherein the first external electrode includes a plurality of conductive layers including a conductive layer made of a material different from a material of a conductive layer of the endmost coil wiring.
**5**. The inductor component according to claim 1, wherein the first external electrode further includes a bottom portion which continuous from the first part of the protrusion to a side opposite to the second part and extends in a direction parallel to the first principal surface; and a wall portion which is continuous from the bottom portion and extends in the first direction.

**6**. The inductor component according to claim 1, wherein the first external electrode further includes a fourth part which is separated from the second part and is closer to the side in the first direction than the second part is.
**7**. The inductor component according to claim 1, wherein the first principal surface has a recess, the recess has a side surface having a stepped shape, and at least a part of the first external electrode has a shape which is in contact with the side surface and conforms to the side surface.
**8**. The inductor component according to claim 1, further comprising: an insulating body provided on a part of the first principal surface, wherein at least a part of the first external electrode is continuously in contact with the insulating body, the first principal surface, and the first side surface of the protrusion.
**9**. The inductor component according to claim 1, wherein the first coil wiring is in the first principal surface, the inductor component further comprises an insulating body that covers the first coil wiring and has a shape conforming to a shape of the first coil wiring, and at least a part of the first external electrode is in contact with the insulating body and has a shape conforming to the shape of the first coil wiring.
**10**. 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.
**11**. 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.
**12**. The inductor component according to claim 1, wherein the element body includes SiO.sub.2, and the first penetration wirings include SiO.sub.2.
**13**. The inductor component according to claim 1, wherein each of the first penetration wirings has a void portion or a resin portion.
**14**. 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 inside the conductive layer.
**15**. The inductor component according to claim 1, wherein the coil has a length in an axial direction thereof which is shorter than an inner diameter of the coil.
**16**. 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.
**17**. The inductor component according to claim 1, wherein the inductor component has a thickness of 200 μm or smaller.
**18**. 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.
**19**. The inductor component according to claim 2, wherein the element body includes SiO.sub.2.
**20**. The inductor component according to claim 2, wherein the first external electrode includes a plurality of conductive layers including a conductive layer made of a material different from a material of a conductive layer of the endmost coil wiring.