US012388414B2

(12) United States Patent
Yamamoto et al.

(10) Patent No.: US 12,388,414 B2
(45) Date of Patent: Aug. 12, 2025

(54) ACOUSTIC WAVE DEVICE

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 752 days.

(21) Appl. No.: **17/750,435**

(22) Filed: **May 23, 2022**

(65) **Prior Publication Data**

US 2022/0278667 A1 Sep. 1, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2020/044914, filed on Dec. 2, 2020.

(30) **Foreign Application Priority Data**

Dec. 9, 2019 (JP) 2019-222040

(51) **Int. Cl.**
H03H 9/02 (2006.01)
H03H 9/145 (2006.01)
H03H 9/25 (2006.01)

(52) **U.S. Cl.**
CPC ***H03H 9/02897*** (2013.01); ***H03H 9/02866*** (2013.01); ***H03H 9/02992*** (2013.01); ***H03H 9/145*** (2013.01); ***H03H 9/25*** (2013.01)

(58) **Field of Classification Search**
CPC H03H 9/02897; H03H 9/02866; H03H 9/02992; H03H 9/145; H03H 9/25
See application file for complete search history.

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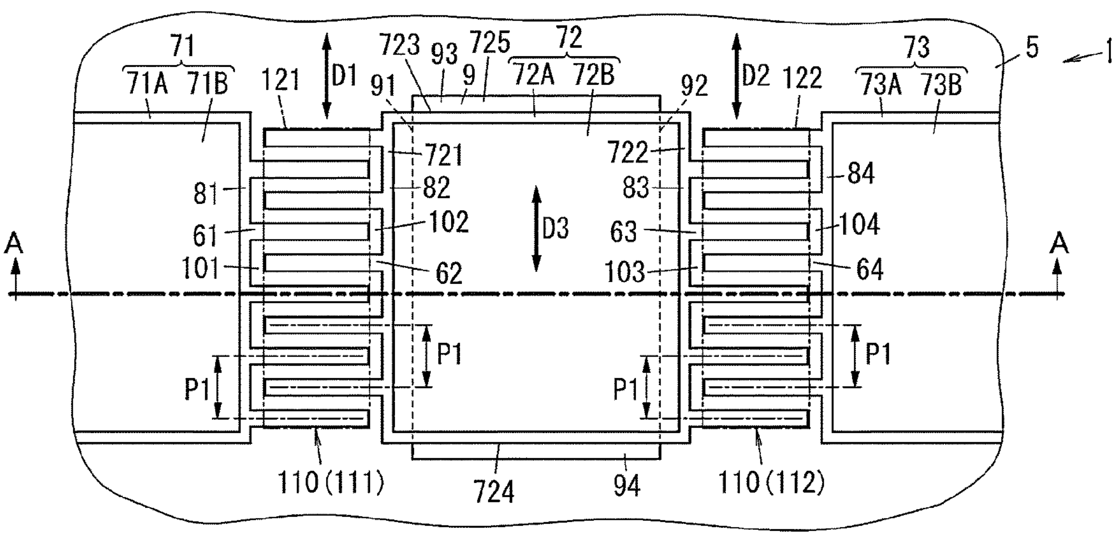
(57) **ABSTRACT**

An acoustic wave device includes first and second electrode fingers on a piezoelectric layer, and third and fourth electrode fingers and a plurality of fourth electrode fingers are provided on the piezoelectric layer. A connection section includes second and third busbars. The second busbar is on the piezoelectric layer and is connected to one end of each of the second electrode fingers. The third busbar is on the piezoelectric layer and is connected to one end of each of the third electrode fingers. A stress relaxation layer is between the connection section and the piezoelectric layer. The stress relaxation layer does not extend to any of a gap between each of the first electrode fingers and the second busbar and a gap between each of the fourth electrode fingers and the third busbar in a plan view from a thickness direction of a support substrate.

18 Claims, 5 Drawing Sheets



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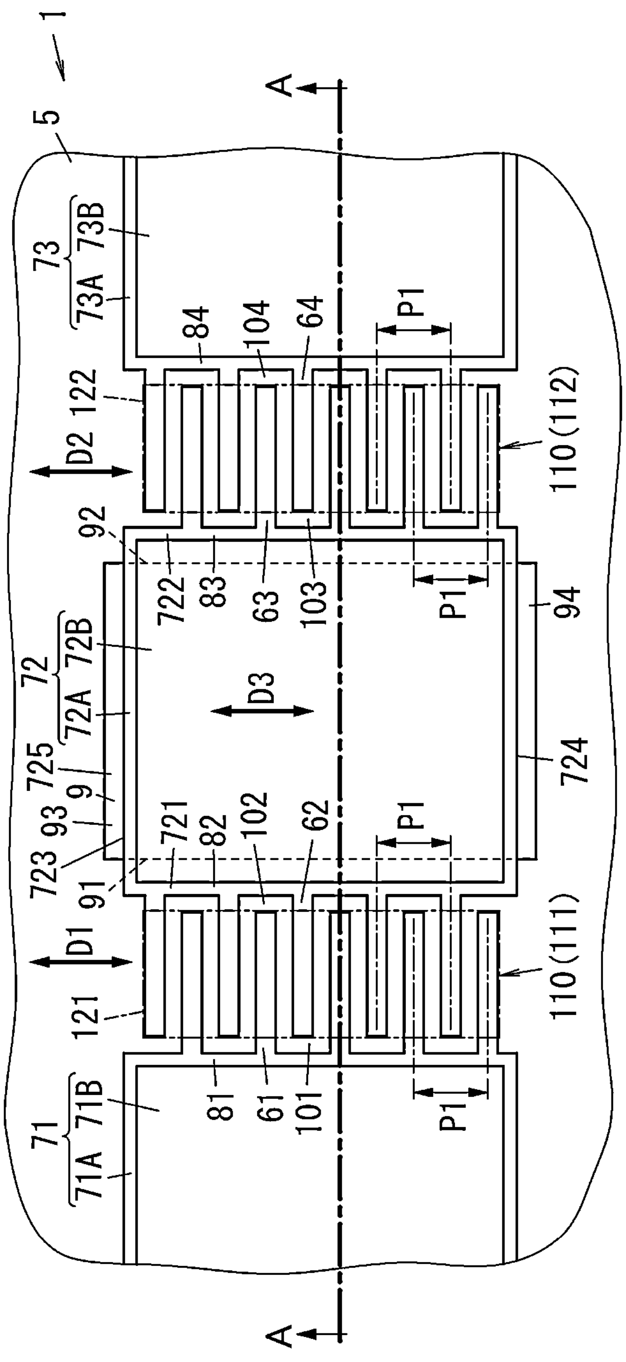
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5
A
73
73A
73B
84
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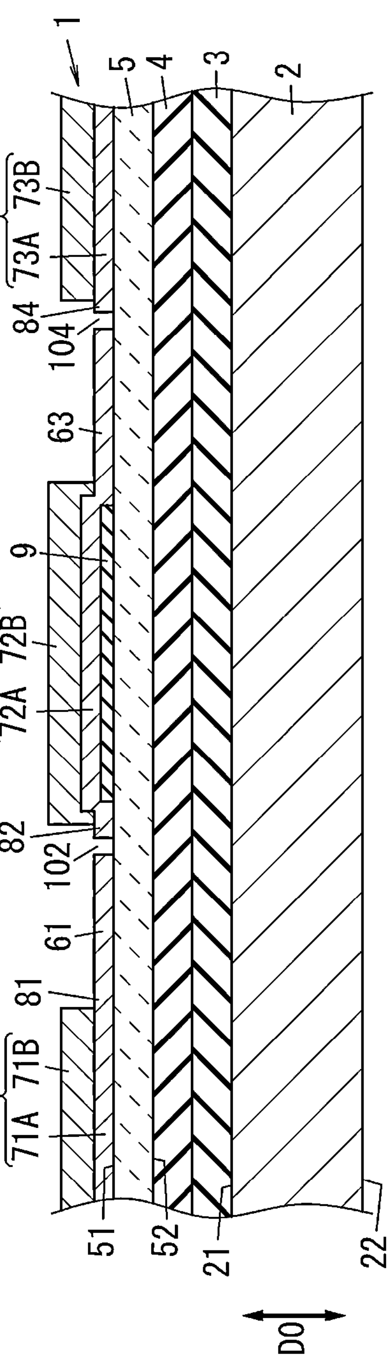
64
P1
122
D2
110(112)
92
722
83
63
103
94
72
72A
72B
D3
725
9
93
723
91
721
82
102
62
724
D1
121
110(111)
71
71A
71B
81
61
101

FIG. 1A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71A
71B
51
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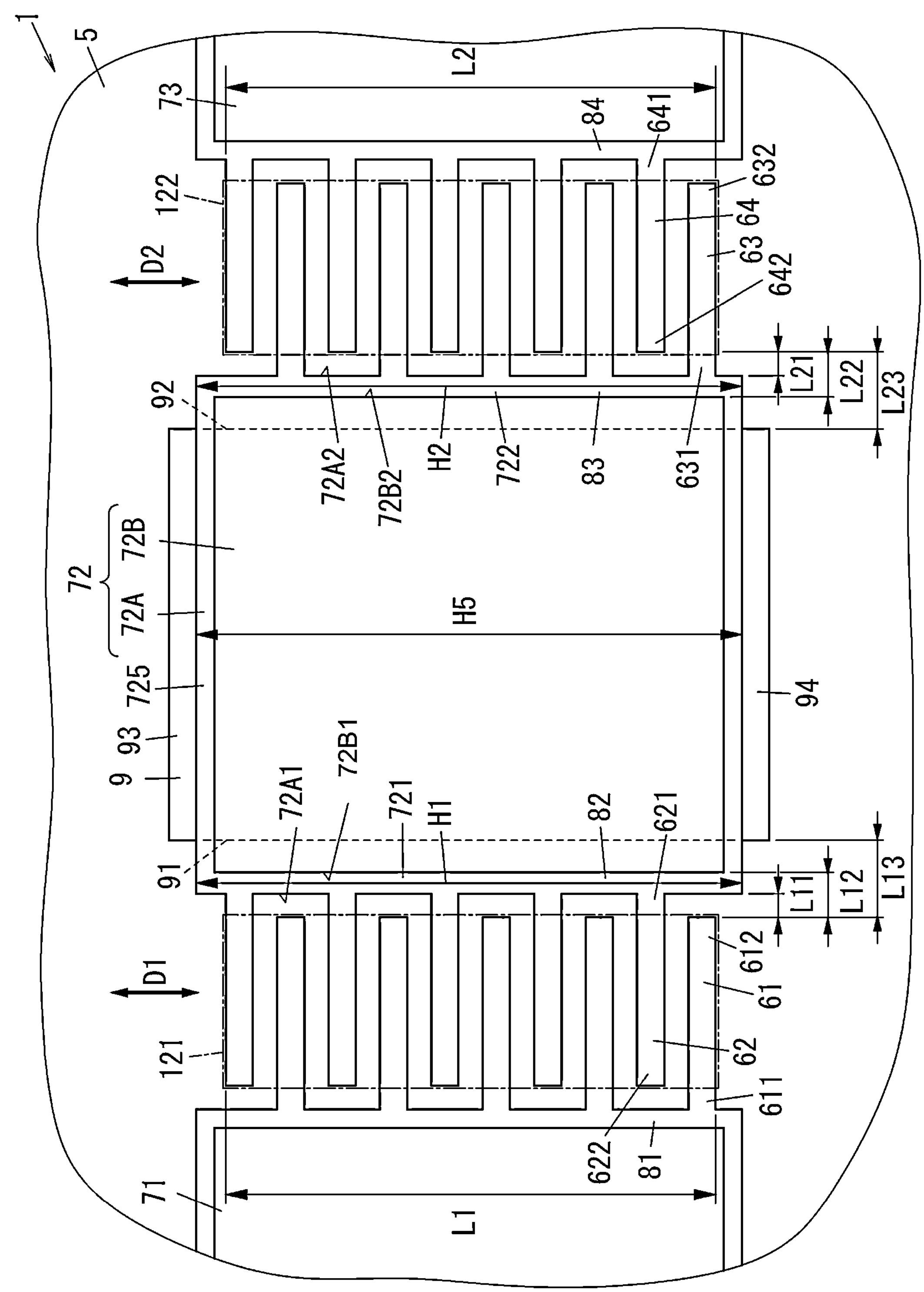
21
22
D0

FIG. 1B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722
83
631
72
72B
72A
H5
725
93
9
94
72A1
72B1
721
H1
82
621
91
L11
L12
L13
612
D1
61
121
62
611
622
81
71
L1

FIG. 2

FIG. 3A

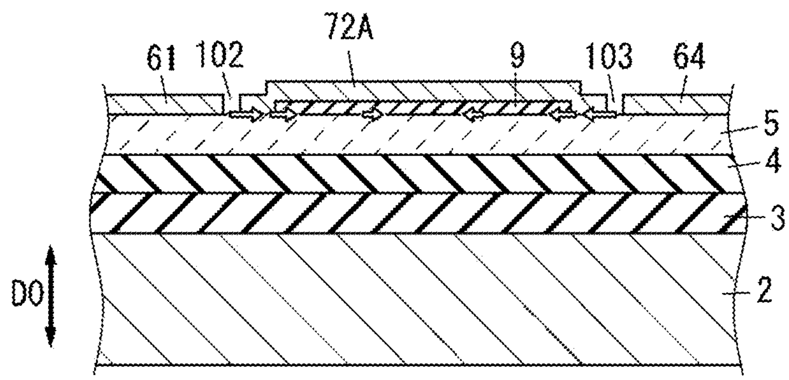
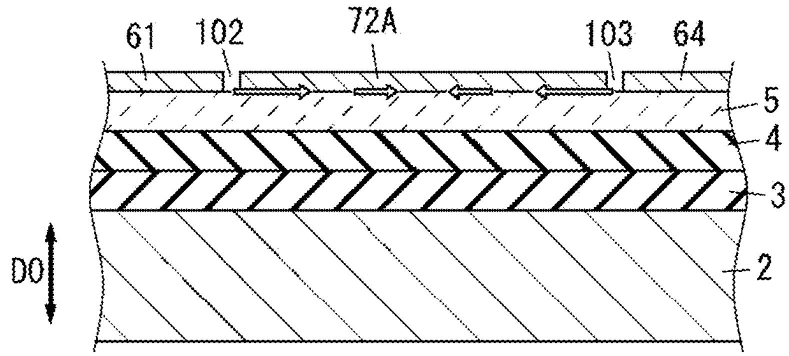
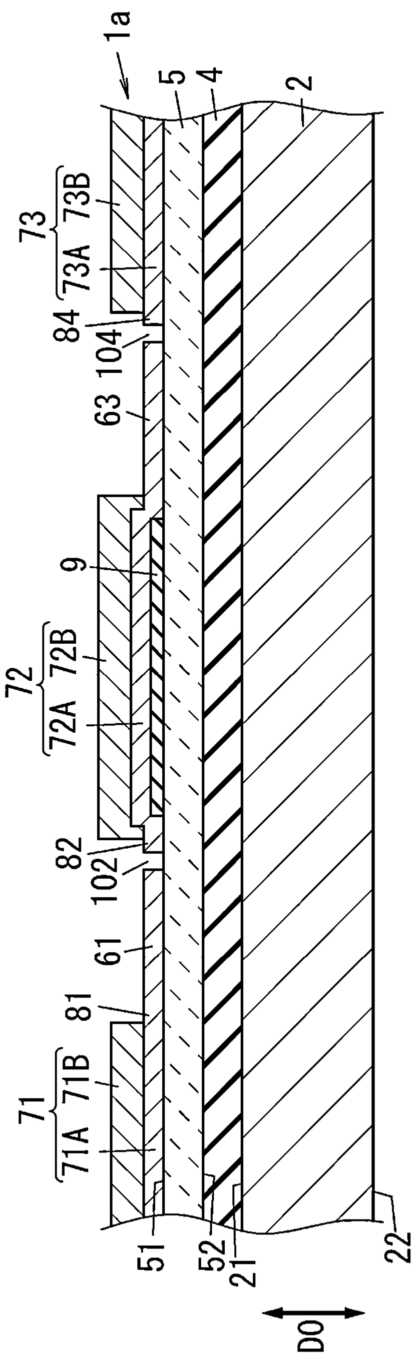


FIG. 3B

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61
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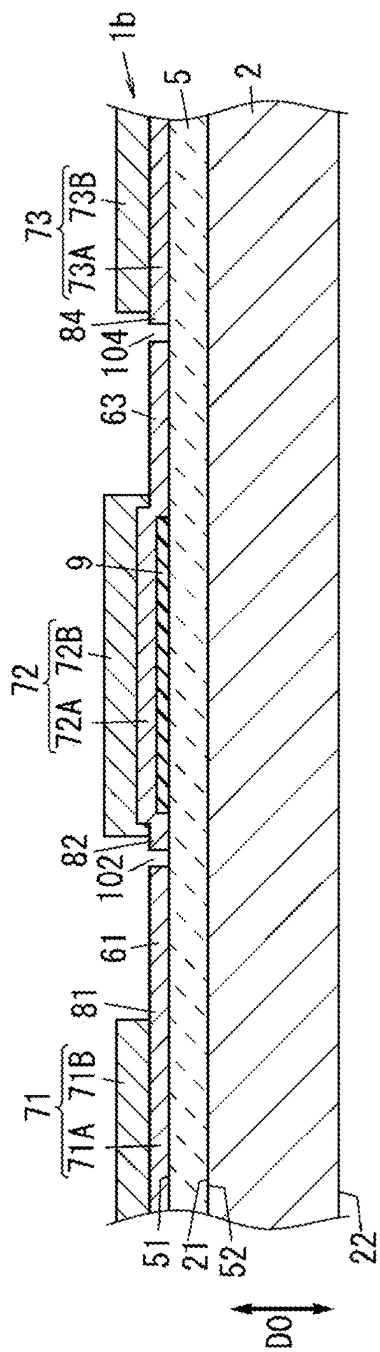
71A
71B
51
52
21
22
D0

FIG. 4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72A
72B
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102
61
81
71
71A
71B
51
21
52
22
D0

FIG. 5

ACOUSTIC WAVE DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority to Japanese Patent Application No. 2019-222040 filed on Dec. 9, 2019 and is a Continuation Application of PCT Application No. PCT/JP2020/044914 filed on Dec. 2, 2020. The entire contents of each application are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to acoustic wave devices, and more specifically to acoustic wave devices including piezoelectric layers.

2. Description of the Related Art

An acoustic wave filter device including a piezoelectric substrate and a plurality of acoustic wave resonators sharing one piezoelectric substrate has been known as an acoustic wave device (see, for example, see Japanese Unexamined Patent Application Publication No. 2017-195580). In an acoustic wave filter device described in Japanese Unexamined Patent Application Publication No. 2017-195580, each of a plurality of acoustic wave resonators includes a piezoelectric substrate and an interdigital transducer (IDT) electrode formed on the piezoelectric substrate and having a pair of comb-shaped electrodes facing each other. Each of the pair of comb-shaped electrodes includes a busbar electrode disposed to extend in an acoustic wave propagation direction, and a plurality of electrode fingers connected to the busbar electrode and disposed to extend in a direction orthogonal to the acoustic wave propagation direction. The acoustic wave filter device further includes connection wiring configured to connect the busbar electrode of one acoustic wave resonator and the busbar electrode of another acoustic wave resonator.

Japanese Unexamined Patent Application Publication No. 2017-195580 describes that the piezoelectric substrate may have a laminated structure in which a high acoustic velocity support substrate, a low acoustic velocity film, and a piezoelectric film (piezoelectric layer) are laminated in that order.

In a case where a piezoelectric substrate has a laminated structure as in the acoustic wave device described in Japanese Unexamined Patent Application Publication No. 2017-195580, a stress applied to the piezoelectric layer may increase due to a difference in a linear expansion coefficient among the piezoelectric layer, the IDT electrode, and the connection wiring. Accordingly, in the piezoelectric layer, there is a concern that polarization reversal occurs in a region overlapping a gap between the busbar electrode and the plurality of electrode fingers of one acoustic wave resonator and in a region overlapping a gap between the busbar electrode and the plurality of electrode fingers of another acoustic wave resonator in a plan view from a thickness direction of the high acoustic velocity support substrate (support substrate).

SUMMARY OF THE INVENTION

Preferred embodiments of the present invention provide acoustic wave devices that are each able to reduce or prevent the occurrence of polarization reversal.

An acoustic wave device according to a preferred embodiment of the present invention includes a support substrate, a piezoelectric layer, a plurality of first electrode fingers and a plurality of second electrode fingers, a plurality of third electrode fingers and a plurality of fourth electrode fingers, a first busbar, a connection section, and a fourth busbar. The piezoelectric layer is on the support substrate. The plurality of first electrode fingers and the plurality of second electrode fingers are on the piezoelectric layer. The plurality of first electrode fingers and the plurality of second electrode fingers are spaced apart from each other in a first direction intersecting a thickness direction of the support substrate. The plurality of third electrode fingers and the plurality of fourth electrode fingers are on the piezoelectric layer. The plurality of third electrode fingers and the plurality of fourth electrode fingers are spaced apart from each other in a second direction intersecting the thickness direction of the support substrate. The first busbar is on the piezoelectric layer and is connected to one end of each of the plurality of first electrode fingers. The connection section includes a second busbar and a third busbar. The second busbar is on the piezoelectric layer and is connected to one end of each of the plurality of second electrode fingers. The third busbar is on the piezoelectric layer and is connected to one end of each of the plurality of third electrode fingers. The fourth busbar is on the piezoelectric layer and is connected to one end of each of the plurality of fourth electrode fingers. The acoustic wave device further includes a stress relaxation layer. The stress relaxation layer is between the connection section and the piezoelectric layer. The second busbar faces the other end of each of the plurality of first electrode fingers. The third busbar faces the other end of each of the plurality of fourth electrode fingers. The stress relaxation layer does not extend to either of a gap between the plurality of first electrode fingers and the second busbar or a gap between the plurality of fourth electrode fingers and the third busbar in a plan view from the thickness direction of the support substrate.

The acoustic wave devices according to preferred embodiments of the present invention are able to reduce or prevent the occurrence of polarization reversal.

The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a plan view of an acoustic wave device according to Preferred Embodiment 1 of the present invention. FIG. **1**B is a cross-sectional view of the acoustic wave device taken along a line A-A in FIG. **1**A.

FIG. **2** is an explanatory diagram of dimensions of the acoustic wave device.

FIG. **3**A is an explanatory diagram of stresses applied to a first principal surface of a piezoelectric layer. FIG. **3**B is an explanatory diagram of stresses applied to a first principal surface of a piezoelectric layer in a case where a stress relaxation layer is not provided.

FIG. **4** is a cross-sectional view of an acoustic wave device according to Preferred Embodiment 2 of the present invention.

FIG. **5** is a cross-sectional view of an acoustic wave device according to Preferred Embodiment 3 of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1**A, **1**B, **2**, **3**A, **3**B, **4**, and **5** describing Preferred Embodiments 1 to 3 of the present invention are all schematic drawings, and ratios of sizes, thicknesses, and the like of elements in the drawings do not necessarily reflect actual dimensional ratios.

Preferred Embodiment 1

(1) Overall Configuration of Acoustic Wave Device

Hereinafter, an acoustic wave device **1** according to Preferred Embodiment 1 of the present invention will be described with reference to FIGS. **1**A, **1**B, and **2**.

The acoustic wave device **1** includes a support substrate **2**, a piezoelectric layer **5**, a plurality of first electrode fingers **61**, a plurality of second electrode fingers **62**, a plurality of third electrode fingers **63**, a plurality of fourth electrode fingers **64**, a first connection section **71**, a second connection section **72** (connection section), and a third connection section **73**. The plurality of first electrode fingers **61** and the plurality of second electrode fingers **62** are provided on the piezoelectric layer **5**. The plurality of third electrode fingers **63** and the plurality of fourth electrode fingers **64** are provided on the piezoelectric layer **5**. The first connection section **71** is provided on the piezoelectric layer **5**. The first connection section **71** includes a first busbar **81** connected to one end **611** of each of the plurality of first electrode fingers **61**. The second connection section **72** is provided on the piezoelectric layer **5**. The second connection section **72** includes a second busbar **82** and a third busbar **83**. The second busbar **82** is connected to one end **621** of each of the plurality of second electrode fingers **62** and faces the first busbar **81** and the plurality of first electrode fingers **61**. The third busbar **83** is connected to one end **631** of each of the plurality of third electrode fingers **63**. The third connection section **73** is provided on the piezoelectric layer **5**. The third connection section **73** includes a fourth busbar **84**. The fourth busbar **84** is connected to one end **641** of each of the plurality of fourth electrode fingers **64** and faces the third busbar **83** and the plurality of third electrode fingers **63**. The acoustic wave device further includes a stress relaxation layer **9**. The stress relaxation layer **9** is provided between the second connection section **72** and the piezoelectric layer **5**.

In the acoustic wave device **1**, a first interdigital transducer (IDT) electrode **111** includes the plurality of first electrode fingers **61**, the plurality of second electrode fingers **62**, the first busbar **81**, and the second busbar **82**. In the acoustic wave device **1**, a second IDT electrode **112** includes the plurality of third electrode fingers **63**, the plurality of fourth electrode fingers **64**, the third busbar **83**, and the fourth busbar **84**.

The acoustic wave device **1** further includes a low acoustic velocity film **4** provided between the support substrate **2** and the piezoelectric layer **5**. The acoustic wave device **1** further includes a high acoustic velocity film **3** provided between the support substrate **2** and the low acoustic velocity film **4**.

(2) Elements of Acoustic Wave Device

(2.1) Support Substrate

The support substrate **2** supports the piezoelectric layer **5**. In the acoustic wave device **1** according to Preferred Embodiment 1, the support substrate **2** also supports the high acoustic velocity film **3** and the low acoustic velocity film **4**,

and supports the piezoelectric layer **5** with the high acoustic velocity film **3** and the low acoustic velocity film **4** interposed therebetween.

The support substrate **2** includes a first principal surface **21** and a second principal surface **22** opposing each other. The first principal surface **21** and the second principal surface **22** oppose each other in a thickness direction D**0** of the support substrate **2**. In a plan view from the thickness direction D**0** of the support substrate **2**, the support substrate **2** has a rectangular or substantially rectangular shape, but is not limited thereto, and may have a square or substantially rectangular shape, for example.

The thickness of the support substrate **2** is preferably in a range from about 10λ (λ: wavelength of an acoustic wave determined by an electrode finger pitch P**1**) μm to about 180 μm, and is about 120 μm as an example. The support substrate **2** is, for example, a silicon substrate. In this case, the plane orientation of the first principal surface **21** of the support substrate **2** is, for example, a (100) plane, but is not limited thereto, and may be, for example, a (110) plane or a (111) plane. The propagation orientation of the acoustic wave may be set without being restricted by the plane orientation of the support substrate **2**.

(2.2) Piezoelectric Layer

The piezoelectric layer **5** includes a first principal surface **51** and a second principal surface **52** opposing each other. The first principal surface **51** and the second principal surface **52** oppose each other in the thickness direction D**0** of the support substrate **2**. The first principal surface **51** of the piezoelectric layer **5** is a positive surface in a polarization axis direction of the piezoelectric layer **5**, but is not limited thereto, and may be a negative surface. The positive surface in the polarization axis direction refers to a surface in a direction in which the positive side of the polarization component in the piezoelectric layer **5** faces. The negative surface in the polarization axis direction refers to a surface in a direction in which the negative side of the polarization component in the piezoelectric layer **5** faces.

The piezoelectric layer **5** is made of, for example, a Γ° Y-cut X-propagation $LiTaO_3$ piezoelectric single crystal. When three crystal axes of the $LiTaO_3$ piezoelectric single crystal are defined as an X-axis, a Y-axis, and a Z-axis, the Γ° Y-cut X-propagation $LiTaO_3$ piezoelectric single crystal is a $LiTaO_3$ single crystal obtained by being cut along a plane normal to an axis rotated by Γ° from the Y-axis in a Z-axis direction about the X-axis, and is a single crystal through which a surface acoustic wave propagates in the X-axis direction. The cut-angle of the piezoelectric layer **5** is, when the cut-angle is taken as Γ[°] and the Euler angles of the piezoelectric layer **5** are taken as (φ, θ, Ψ), represented by an equation of $\Gamma=\theta+90°$. Note that "Γ" and "Γ±180×n" are synonymous with each other (crystallographically equivalent). In this case, n is a natural number. The piezoelectric layer **5** is not limited to the Γ° Y-cut X-propagation $LiTaO_3$ piezoelectric single crystal, and may be, for example, Γ° Y-cut X-propagation $LiTaO_3$ piezoelectric ceramics.

The thickness of the piezoelectric layer **5** is, for example, smaller than or equal to about 3.5λ, where λ is a wavelength of the acoustic wave determined by the electrode finger pitch (electrode finger period) P**1** of the first IDT electrode **111** and second IDT electrode **112**. The electrode finger pitch P**1** will be described later in the section of "(2.3) IDT Electrode". The acoustic wave device **1** has a high Q value when the thickness of the piezoelectric layer **5** is equal to or less than about 3.5λ. The acoustic wave device **1** may reduce a temperature coefficient of frequency (TCF) by setting the thickness of the piezoelectric layer **5** to be, for example, about 2.5λ or less. Furthermore, in the acoustic wave device **1**, setting the thickness of the piezoelectric layer **5** to be equal to or less than, for example, about 1.5λ makes it easy to adjust the acoustic velocity of the acoustic wave. The thickness of the piezoelectric layer **5** is not limited to about 3.5λ or less, and may be, for example, larger than about 3.5λ. In the acoustic wave device **1** according to Preferred Embodiment 1, the wavelength of the acoustic wave is about 2.0 μm, for example.

In the acoustic wave device **1**, when the thickness of the piezoelectric layer **5** is about 3.5λ or less, the Q value is raised as described above, but a high-order mode is generated. In the acoustic wave device **1**, the low acoustic velocity film **4** and high acoustic velocity film **3** described above are provided so as to reduce the high-order mode even when the thickness of the piezoelectric layer **5** is about 3.5λ or less.

In the acoustic wave device **1**, as the mode of the acoustic wave propagating through the piezoelectric layer **5**, there exists a longitudinal wave, an SH wave or an SV wave, or a composite mode of these waves. In the acoustic wave device **1**, a mode including an SH wave as a main component is used as a main mode. The high-order mode refers to a spurious mode generated on a higher frequency side relative to the main mode of the acoustic wave propagating through the piezoelectric layer **5**. Whether the mode of the acoustic wave propagating through the piezoelectric layer **5** is "a main mode mainly including an SH wave" may be confirmed, for example, by analyzing the displacement distribution and analyzing the distortion by the finite element method using parameters such as parameters of the piezoelectric layer **5** (material, Euler angles, thickness, and the like), parameters of the first IDT electrode **111** and second IDT electrode **112** (material, thickness, the electrode finger pitch P**1**, and the like), and parameters of the low acoustic velocity film **4** (material, thickness, and the like). The Euler angles of the piezoelectric layer **5** may be obtained by analysis.

The material of the piezoelectric layer **5** is not limited to lithium tantalate ($LiTaO_3$), and may be, for example, lithium niobate ($LiNbO_3$), zinc oxide (ZnO), aluminum nitride (AlN), or lead zirconate titanate (PZT). When the piezoelectric layer **5** is made of, for example, a Y-cut X-propagation $LiNbO_3$ piezoelectric single crystal or piezoelectric ceramics, the acoustic wave device **1** may use, as a main mode, a mode including an SH wave as a main component. The single crystal material and the cut-angles of the piezoelectric layer **5** may be appropriately determined in accordance with, for example, required specifications (filter characteristics such as bandpass characteristics, attenuation characteristics, temperature characteristics, and band width) of a filter included in the acoustic wave device **1**.

(2.3) IDT Electrode

The acoustic wave device **1** includes a plurality of IDT electrodes **110**. The plurality of IDT electrodes **110** include the first IDT electrode **111** and the second IDT electrode **112** described above. The plurality of IDT electrodes **110** are provided on the piezoelectric layer **5**. More specifically, the plurality of IDT electrodes **110** are provided on the first principal surface **51** on the opposite side to the second principal surface **52** on the support substrate **2** side of the piezoelectric layer **5**.

The first IDT electrode **111** includes the first busbar **81**, the second busbar **82**, the plurality of first electrode fingers **61**, and the plurality of second electrode fingers **62**. The second busbar **82** faces the first busbar **81**.

The plurality of first electrode fingers **61** are connected to the first busbar **81** and extends toward the second busbar **82** side. The plurality of first electrode fingers **61** are provided integrally with the first busbar **81** and are separated from the second busbar **82**. In a plan view from the thickness direction D**0** of the support substrate **2**, there is a gap **102** between each of the plurality of first electrode fingers **61** and the second busbar **82**.

The plurality of second electrode fingers **62** are connected to the second busbar **82** and extend toward the first busbar **81** side. The plurality of second electrode fingers **62** are provided integrally with the second busbar **82** and are separated from the first busbar **81**. In the plan view from the thickness direction D**0** of the support substrate **2**, there is a gap **101** between each of the plurality of second electrode fingers **62** and the first busbar **81**.

The first IDT electrode **111** is, for example, a normal IDT electrode. Hereinafter, the first IDT electrode **111** will be described in more detail.

The first busbar **81** and the second busbar **82** of the first IDT electrode **111** have an elongated shape whose longitudinal direction extends in a first direction D**1** orthogonal or substantially orthogonal to the thickness direction D**0** of the support substrate **2**. To rephrase, the first busbar **81** and the second busbar **82** of the first IDT electrode **111** have an elongated shape whose longitudinal direction takes the first direction D**1**, which is an acoustic wave propagation direction. In the first IDT electrode **111**, the first busbar **81** and the second busbar **82** face each other in a direction orthogonal or substantially orthogonal to both the thickness direction D**0** of the support substrate **2** and the first direction D**1** (hereinafter also referred to as a first defined direction).

The plurality of first electrode fingers **61** are connected to the first busbar **81** and extend toward the second busbar **82**. The plurality of first electrode fingers **61** extend from the first busbar **81** along the first defined direction. Tips (the other ends **612**) of the plurality of first electrode fingers **61** are separated from the second busbar **82**. The above-described gap **102** is present between each tip of the plurality of first electrode fingers **61** and the second busbar **82**. For example, each of the plurality of first electrode fingers **61** has the same or substantially the same length and width.

The plurality of second electrode fingers **62** are connected to the second busbar **82** and extend toward the first busbar **81**. The plurality of second electrode fingers **62** extend from the second busbar **82** along the first defined direction. Tips (the other ends **622**) of the plurality of second electrode fingers **62** are separated from the first busbar **81**. The above-described gap **101** is present between each tip of the plurality of second electrode fingers **62** and the first busbar **81**. For example, each of the plurality of second electrode fingers **62** has the same or substantially the same length and width. In the example shown in FIG. **1**A, the length of the plurality of second electrode fingers is the same or substantially the same as the length of the plurality of first electrode fingers **61**. Further, in the example shown in FIG. **1**A, the width of the plurality of second electrode fingers **62** is the same or substantially the same as the width of the plurality of first electrode fingers **61**.

In the first IDT electrode **111**, the plurality of first electrode fingers **61** and the plurality of second electrode fingers are spaced apart from each other in the first direction D**1** intersecting the thickness direction D**0** of the support substrate **2**. In this case, the plurality of first electrode fingers **61** and the plurality of second electrode fingers **62** are alternately arranged one by one and spaced apart from each other in the first direction D**1**, but are not limited thereto. The first electrode finger **61** and the second electrode finger **62** adjacent to each other are separated from each other. The first busbar **81** is a conductor portion that causes the plurality of first electrode fingers **61** to have the same potential. The second busbar **82** is a conductor portion that causes the plurality of second electrode fingers **62** to have the same potential (equipotential).

The first IDT electrode **111** includes an overlap region **121** defined by the plurality of first electrode fingers **61** and the plurality of second electrode fingers **62**. The overlap region **121** is between an envelope of the tips of the plurality of first electrode fingers **61** and an envelope of the tips of the plurality of second electrode fingers **62**. The first IDT electrode **111** excites an acoustic wave in the overlap region **121**.

The electrode finger pitch P**1** of the first IDT electrode **111** is defined by a distance between center lines of two adjacent first electrode fingers **61** among the plurality of first electrode fingers **61** or a distance between center lines of two adjacent second electrode fingers **62** among the plurality of second electrode fingers **62**. The distance between the center lines of two adjacent second electrode fingers **62** is the same or substantially the same as the distance between the center lines of two adjacent first electrode fingers **61**.

In the first IDT electrode **111** of the acoustic wave device **1** according to Preferred Embodiment 1, the number of pairs of the first electrode finger **61** and the second electrode finger **62** is, for example, 100. That is, the first IDT electrode **111** includes, for example, 100 first electrode fingers **61** and 100 second electrode fingers **62**.

The second IDT electrode **112** includes the third busbar **83**, the fourth busbar **84**, the plurality of third electrode fingers **63**, and the plurality of fourth electrode fingers **64**. The fourth busbar **84** faces the third busbar **83**.

The plurality of third electrode fingers **63** are connected to the third busbar **83** and extends toward the fourth busbar **84** side. The plurality of third electrode fingers **63** are provided integrally with the third busbar **83** and are separated from the fourth busbar **84**. In the plan view from the thickness direction D**0** of the support substrate **2**, there is a gap **104** between each of the plurality of third electrode fingers **63** and the fourth busbar **84**.

The plurality of fourth electrode fingers **64** are connected to the fourth busbar **84** and extend toward the third busbar **83** side. The plurality of fourth electrode fingers **64** is provided integrally with the fourth busbar **84** and are separated from the third busbar **83**. In the plan view from the thickness direction D**0** of the support substrate **2**, there is a gap **103** between each of the plurality of fourth electrode fingers **64** and the third busbar **83**.

The second IDT electrode **112** is, for example, a normal IDT electrode. Hereinafter, the second IDT electrode **112** will be described in more detail.

The third busbar **83** and the fourth busbar **84** of the second IDT electrode **112** have an elongated shape whose longitudinal direction takes a second direction D**2** orthogonal or substantially orthogonal to the thickness direction D**0** of the support substrate **2**. In other words, the third busbar **83** and the fourth busbar **84** of the second IDT electrode **112** have an elongated shape whose longitudinal direction extending in the second direction D**2**, which is an acoustic wave propagation direction. In the second IDT electrode **112**, the third busbar **83** and the fourth busbar **84** face each other in a direction orthogonal or substantially orthogonal to both the thickness direction D**0** of the support substrate **2** and the second direction D**2** (hereinafter also referred to as a second defined direction). In the acoustic wave device **1** according to Preferred Embodiment 1, the second direction D**2** is parallel or substantially parallel to the first direction D**1**. Accordingly, the second defined direction is parallel or substantially parallel to the first defined direction.

The plurality of third electrode fingers **63** are connected to the third busbar **83** and extend toward the fourth busbar **84**. The plurality of third electrode fingers **63** extend from the third busbar **83** along the second defined direction. Tips (the other ends **632**) of the plurality of third electrode fingers **63** are separated from the fourth busbar **84**. The above-described gap **104** is present between each tip of the plurality of third electrode fingers **63** and the fourth busbar **84**. For example, each of the plurality of third electrode fingers **63** has the same or substantially the same length and width.

The plurality of fourth electrode fingers **64** are connected to the fourth busbar **84** and extend toward the third busbar **83**. The plurality of fourth electrode fingers **64** extend from the fourth busbar **84** along the second defined direction. Tips (the other ends **642**) of the plurality of fourth electrode fingers **64** are separated from the third busbar **83**. The above-described gap **103** is present between each tip of the plurality of fourth electrode fingers **64** and the third busbar **83**. For example, each of the plurality of fourth electrode fingers **64** has the same or substantially the same length and width. In the example of FIG. **1**A, the length of the plurality of fourth electrode fingers **64** is the same or substantially the same as the length of the plurality of third electrode fingers **63**. Further, in the example of FIG. **1**A, the width of the plurality of fourth electrode fingers **64** is the same or substantially the same as the width of the plurality of third electrode fingers **63**.

In the second IDT electrode **112**, the plurality of third electrode fingers **63** and the plurality of fourth electrode fingers **64** are spaced apart from each other in the second direction D**2** intersecting the thickness direction D**0** of the support substrate **2**. In this case, the plurality of third electrode fingers **63** and the plurality of fourth electrode fingers **64** are alternately arranged one by one and spaced apart from each other in the second direction D**2**, but are not limited thereto. The third electrode finger **63** and the fourth electrode finger **64** adjacent to each other are separated from each other. The third busbar **83** is a conductor portion that causes the plurality of third electrode fingers **63** to have the same potential. The fourth busbar **84** is a conductor portion that causes the plurality of fourth electrode fingers **64** to have the same potential (equipotential).

The second IDT electrode **112** includes an overlap region **122** defined by the plurality of third electrode fingers **63** and the plurality of fourth electrode fingers **64**. The overlap region **122** is between an envelope of the tips of the plurality of third electrode fingers **63** and an envelope of the tips of the plurality of fourth electrode fingers **64**. The second IDT electrode **112** excites an acoustic wave in the overlap region **122**.

The electrode finger pitch P**1** of the second IDT electrode **112** is defined by a distance between center lines of two adjacent third electrode fingers **63** among the plurality of third electrode fingers **63** or a distance between center lines of two adjacent fourth electrode fingers **64** among the plurality of fourth electrode fingers **64**. The distance between the center lines of two adjacent fourth electrode fingers **64** is the same or substantially the same as the distance between the center lines of two adjacent third electrode fingers **63**.

In the second IDT electrode **112** of the acoustic wave device **1** according to Preferred Embodiment 1, the number of pairs of the third electrode finger **63** and the fourth electrode finger **64** is, for example, 100. That is, the second IDT electrode **112** includes, for example, 100 third electrode fingers **63** and 100 fourth electrode fingers **64**.

The plurality of IDT electrodes **110** has conductivity. The material of the plurality of IDT electrodes **110** is, for example, aluminum (Al), copper (Cu), platinum (Pt), gold (Au), silver (Ag), titanium (Ti), nickel (Ni), chromium (Cr), molybdenum (Mo), tungsten (W), tantalum (Ta), magnesium (Mg), iron (Fe), or an alloy mainly including any one of these metals. The plurality of IDT electrodes **110** may have a structure in which a plurality of metal films made of these metals or alloys are laminated. The plurality of IDT electrodes **110** include a laminated film made of, for example, a first metal film made of a Ti film provided on the piezoelectric layer **5** and a second metal film made of an Al film provided on the first metal film. The first metal film defines and functions as a close contact film. The material of the first metal film is Ti, but is not limited thereto, and may be, for example, Cr or NiCr. The material of the second metal film is Al, but is not limited thereto, and may include Al and Cu, for example. The thickness of the first metal film is smaller than the thickness of the second metal film.

(2.4) First Connection Section

The first connection section **71** has conductivity. The first connection section **71** is provided on the piezoelectric layer **5**. The first connection section **71** is provided directly on the first principal surface **51** of the piezoelectric layer **5**.

The first connection section **71** includes the first busbar **81**. The first busbar **81** is connected to the plurality of first electrode fingers **61**. Accordingly, the first connection section **71** is connected to the plurality of first electrode fingers **61** and includes a portion of the first IDT electrode **111**.

The first connection section **71** is integrally provided with the plurality of first electrode fingers **61**. The first connection section **71** extends from the plurality of first electrode fingers **61** to the side opposite to the second busbar **82** side.

The first connection section **71** includes a first layer **71**A and a second layer **71**B. The first layer **71**A is integrally provided with the plurality of first electrode fingers **61**. The second layer **71**B is provided on the opposite side of the first layer **71**A to the piezoelectric layer **5**. The first layer **71**A is made of the same material and has the same or substantially the same thickness as the plurality of first electrode fingers **61**, and is provided integrally with the plurality of first electrode fingers **61**.

The material of the first layer **71**A is, for example, Al, Cu, Pt, Au, Ag, Ti, Ni, Cr, Mo, W, Ta, Mg, Fe, or an alloy mainly including any of these metals. The first layer **71**A may have a structure in which a plurality of metal films made of these metals or alloys is laminated. The first layer **71**A includes a laminated film made of, for example, a first metal film made of a Ti film provided on the piezoelectric layer **5** and a second metal film made of an Al film provided on the first metal film. The first metal film defines and functions as a close contact film. The material of the first metal film is Ti, but is not limited thereto, and may be, for example, Cr or NiCr. The material of the second metal film is Al, but is not limited thereto, and may include Al and Cu, for example.

The material of the second layer **71**B is, for example, Al, but is not limited thereto, and may be, for example, Cu, may include Al and Cu, or may include Al, Cu, Ti, and Pt. In a case where the second layer **71**B includes, for example, Al, Cu, Ti, and Pt, the second layer **71**B may be a laminated film in which, for example, a Ti film, an AlCu film, a Ti film, a Pt film, and a Ti film are provided in that order from the first layer **71**A side. The second layer **71**B is thicker than the first layer **71**A.

(2.5) Second Connection Section

The second connection section **72** has conductivity. The second connection section **72** is provided on the piezoelectric layer **5**. A portion of the second connection section **72** is directly provided on the first principal surface **51** of the piezoelectric layer **5**, and the remaining portion thereof is indirectly provided on the first principal surface **51** of the piezoelectric layer **5** with the stress relaxation layer **9** interposed therebetween.

The second connection section **72** includes the second busbar **82** and the third busbar **83**. The second busbar **82** is connected to the plurality of second electrode fingers **62**, and faces the first busbar **81** and the plurality of first electrode fingers **61**. The third busbar **83** is connected to the plurality of third electrode fingers **63**. Accordingly, the second connection section **72** is connected to the plurality of second electrode fingers **62** and the plurality of third electrode fingers **63**, and includes a portion of the first IDT electrode **111** and a portion of the second IDT electrode **112**. The second connection section **72** includes a first connection end portion **721** including the second busbar **82** and a second connection end portion **722** including the third busbar **83**. In the second connection section **72**, a width H**1** (see FIG. **2**) of the first connection end portion **721** in the first direction D**1** is longer than a first length L**1** (see FIG. **2**), which is a length in the first direction D**1** of the overlap region **121** of the plurality of first electrode fingers **61** and the plurality of second electrode fingers **62**. From the viewpoint of lowering the resistance of the second connection section **72**, the width H**1** is preferably equal to or greater than the first length L**1**. In the second connection section **72**, a width H**2** of the second connection end portion **722** in the second direction D**2** is longer than a second length L**2** (see FIG. **2**), which is a length in the second direction D**2** of the overlap region **122** of the plurality of third electrode fingers **63** and the plurality of fourth electrode fingers **64**. From the viewpoint of lowering the resistance of the second connection section **72**, the width H**2** is preferably equal to or greater than the second length L**2**. In the second connection section **72**, a width H**5** (see FIG. **2**) in a portion **725** between the first connection end portion **721** and the second connection end portion **722** may be smaller than the first length L**1** and the second length L**2**, but is preferably not smaller than any of the first length L**1** and the second length L**2** from the viewpoint of lowering the resistance of the second connection section **72**.

The second connection section **72** is integrally provided with the plurality of second electrode fingers **62** and the plurality of third electrode fingers **63**. The second connection section **72** extends toward the opposite side relative to the first busbar **81** side when viewed from the plurality of second electrode fingers **62**. The second connection section **72** extends toward the opposite side relative to the fourth busbar **84** side when viewed from the plurality of third electrode fingers **63**.

The second connection section **72** includes a first layer (lower layer) **72**A and a second layer (upper layer) **72**B. The first layer **72**A is made of the same material and has the same or substantially the same thickness as the plurality of second electrode fingers **62** and the plurality of third electrode fingers **63**, and is provided integrally with the plurality of second electrode fingers **62** and the plurality of third electrode fingers **63**. The second layer **72**B is provided on the opposite side of the first layer **72**A to the piezoelectric layer **5**. The second layer **72**B is made of the same material and has the same or substantially the same thickness as the second layer **71**B of the first connection section **71**. In the acoustic wave device **1** according to Preferred Embodiment

1, the plurality of second electrode fingers **62** and the plurality of third electrode fingers **63** are electrically connected to each other only via the second connection section **72**. The second connection section **72** includes no pad electrode.

The material of the first layer **72**A is, for example, Al, Cu, Pt, Au, Ag, Ti, Ni, Cr, Mo, W, Ta, Mg, Fe, or an alloy mainly including any of these metals. The first layer **71**A may have a structure in which a plurality of metal films made of these metals or alloys is laminated. The first layer **72**A includes a laminated film provided of, for example, a first metal film made of a Ti film provided on the piezoelectric layer **5** and a second metal film made of an Al film provided on the first metal film. The first metal film defines and functions as a close contact film. The material of the first metal film is Ti, but is not limited thereto, and may be, for example, Cr or NiCr. The material of the second metal film is Al, but is not limited thereto, and may include Al and Cu, for example.

The material of the second layer **72**B is, for example, Al, but is not limited thereto, and may be Cu, may include Al and Cu, or may include Al, Cu, Ti, and Pt, for example. In a case where the second layer **72**B includes, for example, Al, Cu, Ti, and Pt, the second layer **72**B may be a laminated film in which a Ti film, an AlCu film, a Ti film, a Pt film, and a Ti film are arranged in that order from the first layer **72**A side. The second layer **72**B is thicker than the first layer **72**A.

It is sufficient for the second connection section **72** to include, of the first layer **72**A and the second layer **72**B, at least the first layer **72**A. From the viewpoint of lowering the resistance of the second connection section **72**, it is preferable for the second connection section **72** to include both the first layer **72**A and the second layer **72**B. In a case where the second connection section **72** includes both the first layer **72**A and the second layer **72**B, it is preferable that both the first layer **72**A and the second layer **72**B have a length equal to or longer than the first length L**1** and the second length L**2** in a third direction D**3**.

(2.6) Third Connection Section

The third connection section **73** has conductivity. The third connection section **73** is provided on the piezoelectric layer **5**. The third connection section **73** is provided directly on the first principal surface **51** of the piezoelectric layer **5**.

The third connection section **73** includes the fourth busbar **84**. The fourth busbar **84** is connected to the plurality of fourth electrode fingers **64**. Accordingly, the third connection section **73** is connected to the plurality of fourth electrode fingers **64**, and includes a portion of the second IDT electrode **112**.

The third connection section **73** is integrally provided with the plurality of fourth electrode fingers **64**. The third connection section **73** extends from the plurality of fourth electrode fingers **64** to the side opposite to the third busbar **83** side.

The third connection section **73** includes a first layer **73**A and a second layer **73**B. The first layer **73**A is integrally provided with the plurality of fourth electrode fingers **64**. The second layer **73**B is provided on the opposite side of the first layer **73**A to the piezoelectric layer **5**. The first layer **73**A is made of the same material and has the same or substantially the same thickness as the plurality of fourth electrode fingers **64**, and is provided integrally with the plurality of fourth electrode fingers **64**.

The material of the first layer **73**A is, for example, Al, Cu, Pt, Au, Ag, Ti, Ni, Cr, Mo, W, Ta, Mg, Fe, or an alloy mainly including any of these metals. The first layer **73**A may have a structure including a plurality of metal films made of these metals or alloys is laminated. The first layer **73**A includes a laminated film including, for example, a first metal film made of a Ti film provided on the piezoelectric layer **5** and a second metal film made of an Al film provided on the first metal film. The first metal film defines and functions as a close contact film. The material of the first metal film is, for example, Ti, but is not limited thereto, and may be, for example, Cr or NiCr. The material of the second metal film is, for example, Al, but is not limited thereto, and may include Al and Cu, for example.

The material of the second layer **73**B is, for example, Al, but is not limited thereto, and may be Cu, may include Al and Cu, or may include Al, Cu, Ti, and Pt, for example. In a case where the second layer **73**B includes, for example, Al, Cu, Ti, and Pt, the second layer **73**B may be a laminated film in which a Ti film, an AlCu film, a Ti film, a Pt film, and a Ti film are arranged in that order from the first layer **73**A side. The second layer **73**B is thicker than the first layer **73**A.

(2.7) Stress Relaxation Layer

The stress relaxation layer **9** is provided between the second connection section **72** and the piezoelectric layer **5**. The stress relaxation layer **9** does not extend any of the gap **102** between each of the plurality of first electrode fingers **61** and the second busbar **82** and a gap **103** between each of the plurality of fourth electrode fingers **64** and the third busbar **83** in a plan view from the thickness direction D**0** of the support substrate **2**. The stress relaxation layer **9** is one piece between the plurality of second electrode fingers **62** and the plurality of third electrode fingers **63**. In other words, only one stress relaxation layer **9** is provided on the first principal surface **51** of the piezoelectric layer **5** between the second connection section **72** and the piezoelectric layer **5**, and is one continuous layer that is not divided into a plurality of portions on the first principal surface **51** of the piezoelectric layer **5**.

The material of the stress relaxation layer **9** is, for example, silicon oxide or polyimide, but is not limited thereto, and may be, for example, hafnium oxide (HfO_2), niobium oxide (Nb_2O_5), tantalum oxide (Ta_2O_5), tungsten oxide (WO_3), or cerium oxide (CeO_2).

In a plan view from the thickness direction D**0** of the support substrate **2**, the stress relaxation layer **9** has a rectangular or substantially rectangular shape, for example, but is not limited thereto, and may have a square or substantially square shape, for example. The stress relaxation layer **9** intersects (here, is orthogonal to) the second connection section **72** in the plan view from the thickness direction D**0** of the support substrate **2**. The stress relaxation layer **9** includes a first projection **93** and a second projection **94**. The first projection **93** projects from a first end **723** in a width direction D**3** of the second connection section **72** in the plan view from the thickness direction D**0** of the support substrate **2**. In the acoustic wave device **1** according to Preferred Embodiment 1, the width direction D**3** of the second connection section **72** is parallel or substantially parallel to the first direction D**1** and the second direction D**2**, but is not limited thereto, and may be non-parallel to those directions. The second connection section **72** corresponds to a wiring width direction that defines a wiring width when a portion of the second connection section **72** excluding the second busbar **82** and the third busbar **83** is considered as wiring. The second projection **94** projects from a second end **724** in the width direction D**3** of the second connection section **72** in the plan view from the thickness direction D**0** of the support substrate **2**.

In the acoustic wave device **1**, in the plan view from the thickness direction D**0** of the support substrate **2**, a distance L**13** (see FIG. **2**) between an end **91** of the stress relaxation layer **9** on the plurality of second electrode fingers **62** side and the plurality of first electrode fingers **61** is longer than a distance L**11** (see FIG. **2**) between an end **72A1** of the first layer **72**A of the second connection section **72** on the plurality of second electrode fingers **62** side and the plurality of first electrode fingers **61**. In a case where there is a variation in length of the plurality of first electrode fingers **61**, a distance between the end **91** of the stress relaxation layer **9** on the plurality of second electrode fingers **62** side and the longest first electrode finger **61** (the first electrode finger **61**, the tip of which is closest to the second connection section **72**) among the plurality of first electrode fingers **61** is taken as the distance L**13**.

In the acoustic wave device **1**, in the plan view from the thickness direction D**0** of the support substrate **2**, a distance L**23** (see FIG. **2**) between an end **92** of the stress relaxation layer **9** on the plurality of third electrode fingers **63** side and the plurality of fourth electrode fingers **64** is longer than a distance L**21** (see FIG. **2**) between an end **72A2** of the first layer **72**A of the second connection section **72** on the plurality of third electrode fingers **63** side and the plurality of fourth electrode fingers **64**. In a case where there is a variation in length of the plurality of fourth electrode fingers **64**, a distance between the end **92** of the stress relaxation layer **9** on the plurality of third electrode fingers **63** side and the longest fourth electrode finger **64** (the fourth electrode finger **64**, the tip of which is closest to the second connection section **72**) among the plurality of fourth electrode fingers **64** is taken as the distance L**23**.

In the acoustic wave device **1**, in the plan view from the thickness direction D**0** of the support substrate **2**, the distance L**13** (see FIG. **2**) between the end **91** of the stress relaxation layer **9** on the plurality of second electrode fingers **62** side and the plurality of first electrode fingers **61** is longer than a distance L**12** (see FIG. **2**) between an end **72B1** of the second layer **72**B on the plurality of second electrode fingers **62** side and the plurality of first electrode fingers **61**.

In the acoustic wave device **1**, in the plan view from the thickness direction D**0** of the support substrate **2**, the distance L**23** (see FIG. **2**) between the end **92** of the stress relaxation layer **9** on the plurality of third electrode fingers **63** side and the plurality of fourth electrode fingers **64** is longer than a distance L**22** (see FIG. **2**) between an end **72B2** of the second layer **72**B on the plurality of third electrode fingers **63** side and the plurality of fourth electrode fingers **64**, as illustrated in FIG. **2**.

(2.8) Low Acoustic Velocity Film

The low acoustic velocity film **4** is provided between the piezoelectric layer **5** and the support substrate **2**. In the acoustic wave device **1** according to Preferred Embodiment 1, the low acoustic velocity film **4** is indirectly provided on the support substrate **2** with the high acoustic velocity film **3** interposed therebetween.

The low acoustic velocity film **4** is a film such that the acoustic velocity of a bulk wave propagating through the low acoustic velocity film **4** is lower than the acoustic velocity of a bulk wave propagating through the piezoelectric layer **5**. In the support substrate **2**, the acoustic velocity of a bulk wave propagating through the support substrate **2** is higher than the acoustic velocity of an acoustic wave propagating through the piezoelectric layer **5**. In this case, the bulk wave propagating through the support substrate **2** is a bulk wave having the lowest acoustic velocity among a plurality of the bulk waves propagating through the support substrate **2**.

In the acoustic wave device **1** according to Preferred Embodiment 1, the low acoustic velocity film **4** is provided between the high acoustic velocity film **3** and the piezoelectric layer **5**. In the acoustic wave device **1**, the low acoustic velocity film **4** is provided between the high acoustic velocity film **3** and the piezoelectric layer **5**, which lowers the acoustic velocity of the acoustic wave. The acoustic wave has a property that energy is concentrated in a medium of low acoustic velocity. Accordingly, it is possible to improve the effect of confining the energy of the acoustic wave in each of the piezoelectric layer **5**, and the first IDT electrode **111** and the second IDT electrode **112**, where the acoustic wave is excited. As a result, the acoustic wave device **1** may reduce the loss and increase the Q value as compared with the case where the low acoustic velocity film **4** is not provided.

The material of the low acoustic velocity film **4** is, for example, silicon oxide. The material of the low acoustic velocity film **4** is not limited to silicon oxide. The material of the low acoustic velocity film **4** may be, for example, glass, silicon oxynitride, tantalum oxide, a compound obtained by adding fluorine, carbon or boron to silicon oxide, or a material containing any of the above materials as a main ingredient.

When the low acoustic velocity film **4** is made of silicon oxide, the acoustic wave device **1** may improve temperature characteristics. Lithium tantalate has negative temperature characteristics, while silicon oxide has positive temperature characteristics. Thus, in the acoustic wave device **1**, the absolute value of the TCF may be decreased.

The thickness of the low acoustic velocity film **4** is preferably, for example, about 2.0λ or less, where λ is a wavelength of the acoustic wave determined by the electrode finger pitch P**1** described above. The low acoustic velocity film **4** is, for example, about 670 nm in thickness. By setting the thickness of the low acoustic velocity film **4** to be about 2.0λ or less, the film stress may be reduced. As a result, a warp in a wafer (for example, a silicon wafer) which is a base of the support substrate **2** may be reduced at the time of manufacturing the acoustic wave device **1**, thereby making it possible to improve the non-defective rate and stabilize the characteristics.

(2.9) High Acoustic Velocity Film

The high acoustic velocity film **3** is provided between the support substrate **2** and the low acoustic velocity film **4**. In this case, the high acoustic velocity film **3** is provided directly on the first principal surface **21** of the support substrate **2**. The high acoustic velocity film **3** is a film such that the acoustic velocity of a bulk wave propagating through the high acoustic velocity film **3** is higher than the acoustic velocity of an acoustic wave propagating through the piezoelectric layer **5**. The thickness of the high acoustic velocity film **3** is, for example, about 200 nm, about 300 nm, or about 400 nm.

The high acoustic velocity film **3** reduces or prevents the leakage of energy of the main mode acoustic wave to a structure below the high acoustic velocity film **3**. In the acoustic wave device **1**, when the high acoustic velocity film **3** is sufficiently thick, the energy of the main mode acoustic wave is distributed throughout the piezoelectric layer **5** and the low acoustic velocity film **4**, is also distributed in part of the high acoustic velocity film **3** on the low acoustic velocity film **4** side, and is not distributed in the support substrate **2**. The mechanism configured to confine the acoustic wave by the high acoustic velocity film **3** is the same as or similar to a mechanism in a case of a surface acoustic wave of a Love wave type, which is a non-leakage SH wave. The mechanism in the case of the Love wave-type surface acoustic wave is described, for example, in the document "Introduction to Simulation Technologies for Surface Acoustic Wave Device", Ken-ya Hashimoto, REALIZE Science & Engineering, pp. 26-28. This mechanism is different from a mechanism in which an acoustic wave is confined using a Bragg reflector by an acoustic multilayer film.

The material of the high acoustic velocity film **3** is, for example, silicon nitride. The material of the high acoustic velocity film **3** is not limited to silicon nitride, and may be, for example, at least one material selected from the group consisting of diamond-like carbon, aluminum nitride, aluminum oxide, silicon carbide, silicon, sapphire, a piezoelectric body (lithium tantalate, lithium niobate, or crystal), alumina, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond. The material of the high acoustic velocity film **3** may be a material containing any of the above-described materials as a main ingredient or a material containing, as a main ingredient, a mixture including any of the above-described materials.

(3) Manufacturing Method for Acoustic Wave Device

Hereinafter, a non-limiting example of a manufacturing method for the acoustic wave device **1** will be briefly described.

In the manufacturing method for the acoustic wave device **1**, at least first to fifth steps described below are performed.

In the first step, a piezoelectricity substrate having a laminated structure including the support substrate **2**, the high acoustic velocity film **3**, the low acoustic velocity film **4**, and the piezoelectric layer **5** is prepared.

In the second step, the stress relaxation layer **9** is formed on the first principal surface **51** of the piezoelectric layer **5** in the piezoelectricity substrate. When the material of the stress relaxation layer **9** is, for example, silicon oxide, the stress relaxation layer **9** is formed by using, for example, a film-formation technique, a photolithography technique, and an etching technique. When the material of the stress relaxation layer **9** is, for example, polyimide, in the second step, the stress relaxation layer **9** is formed by using, for example, the photolithography technique.

In the second step, a resist layer is formed on the first principal surface **51** of the piezoelectric layer **5** in the piezoelectricity substrate. In this case, in the second step, a first resist layer is formed that is patterned so as to expose, in the first principal surface **51** of the piezoelectric layer **5**, formation-expected regions for the plurality of first electrode fingers **61**, the plurality of second electrode fingers **62**, the plurality of third electrode fingers **63**, the plurality of fourth electrode fingers **64**, the first layer **71**A of the first connection section **71**, the first layer **72**A of the second connection section **72**, and the first layer **73**A of the third connection section **73**.

In the third step, a laminated film to be a base including the plurality of first electrode finger **61**, the plurality of second electrode fingers **62**, the plurality of third electrode fingers **63**, the plurality of fourth electrode fingers **64**, the first layer **71**A of the first connection section **71**, the first layer **72**A of the second connection section **72**, and the first layer **73**A of the third connection section **73** is formed on the piezoelectric layer **5** (on the exposed regions in the first principal surface **51** of the piezoelectric layer **5** and on the surface of the stress relaxation layer **9**) by vapor deposition. The laminated film has a laminated structure including the first metal film (for example, a Ti film) and the second metal film (for example, an Al film) on the first metal film.

In the fourth step, the laminated film is patterned through removing the first resist layer and unnecessary films on the first resist layer by performing, for example, lift-off. As a result, in the fourth step, of the laminated film, portions corresponding to the plurality of first electrode fingers **61**, the plurality of second electrode fingers **62**, the plurality of third electrode fingers **63**, the plurality of fourth electrode fingers **64**, the first layer **71**A of the first connection section **71**, the first layer **72**A of the second connection section **72**, and the first layer **73**A of the third connection section **73** are left on the piezoelectric layer **5**. In this case, the unnecessary films are portions formed on the first resist layer in the laminated film having been formed in the third step.

In the fifth step, the second layer **71**B of the first connection section **71**, the second layer **72**B of the second connection section **72**, and the second layer **73**B of the third connection section **73** are formed. The second layer **71**B of the first connection section **71**, the second layer **72**B of the second connection section **72**, and the second layer **73**B of the third connection section **73** are formed utilizing a thin film-formation technique (for example, vapor deposition or sputtering), a photolithography technique, and an etching technique, but are not limited to utilizing these techniques, and may be formed utilizing a lift-off technique, for example.

In the manufacturing method for the acoustic wave device **1**, after the fifth step, a wafer including a plurality of the acoustic wave devices **1** is cut with a dicing machine to produce a plurality of pieces of acoustic wave devices **1** (chips). The manufacturing method for the acoustic wave device **1** is an example and is not particularly limited.

(4) Summary

The acoustic wave device **1** according to Preferred Embodiment 1 includes the stress relaxation layer **9** provided between the second connection section **72** and the piezoelectric layer **5**. In this case, the stress relaxation layer **9** does not extend to any of the gap **102** between each of the plurality of first electrode fingers **61** and the second busbar **82** and the gap **103** between each of the plurality of fourth electrode fingers **64** and the third busbar **83** in a plan view from the thickness direction D**0** of the support substrate **2**.

The acoustic wave device **1** according to Preferred Embodiment 1 may reduce or prevent the occurrence of polarization reversal. Whether the polarization reversal occurs in a region overlapping each of the gaps **102** and **103** in the piezoelectric layer **5** may be confirmed by observation using a scanning probe microscope, for example.

FIG. **3**A is an explanatory diagram of stresses applied to the first principal surface **51** of the piezoelectric layer **5**. FIG. **3**B is an explanatory diagram of stresses applied to the first principal surface **51** of the piezoelectric layer **5** in a case where the stress relaxation layer **9** is not provided. FIGS. **3**A and **3**B are diagrams for explaining a presumed mechanism in which the stresses applied to the first principal surface **51** of the piezoelectric layer **5** are relaxed by the stress relaxation layer **9**. In each of FIGS. **3**A and **3**B, arrows along the first principal surface **51** of the piezoelectric layer **5** represent directions of the stresses applied to the first principal surface **51**, and the magnitude of the stresses is indicated by the lengths of the arrows. That is, the longer the arrow, the larger the stress is, and the shorter the arrow, the smaller the stress is. In a configuration in which the piezoelectric layer **5** and the support substrate **2** are directly or indirectly bonded to each other, stresses applied to regions overlapping the gaps **102** and **103** on the first principal surface **51** of the piezoelectric layer **5** due to a difference in linear expansion coefficient between the piezoelectric layer **5** and the first layer **72**A of the second connection section **72** become larger in some cases affected by a difference in linear expansion coefficient between the piezoelectric layer **5** and the support substrate **2**, as compared to the acoustic wave device having a configuration in which the piezoelectric layer **5** also serves as the support substrate. In the case where the stress relaxation layer **9** is provided, because the stress relaxation layer **9** absorbs the stress from the second connection section **72**, it is possible to relax the stresses applied to the regions overlapping the gaps **102** and **103** on the first principal surface **51** of the piezoelectric layer **5**, as compared to the case where the stress relaxation layer is not provided. In the configuration including the stress relaxation layer **9**, the average value of the magnitude of the stresses applied to the regions overlapping the gaps **102** and **103** on the first principal surface **51** of the piezoelectric layer **5** may be reduced by about 20%, for example, compared to the configuration not including the stress relaxation layer **9**.

Preferred Embodiment 2

Next, an acoustic wave device **1***a* according to Preferred Embodiment 2 of the present invention will be described with reference to FIG. **4**. As for the acoustic wave device **1***a* according to Preferred Embodiment 2, the same or corresponding elements as those of the acoustic wave device **1** according to Preferred Embodiment 1 are denoted by the same reference signs, and description thereof will be omitted.

The acoustic wave device **1***a* according to Preferred Embodiment 2 is different from the acoustic wave device **1** according to Preferred Embodiment 1 in that the high acoustic velocity film **3** of the acoustic wave device **1** according to Preferred Embodiment 1 is not provided. That is, in the acoustic wave device **1***a* according to Preferred Embodiment 2, a low acoustic velocity film **4** is provided directly on a first principal surface **21** of a support substrate **2**.

The acoustic wave device **1***a* according to Preferred Embodiment 2 includes the same or substantially the same stress relaxation layer **9** as that of the acoustic wave device **1** according to Preferred Embodiment 1, which makes it possible to suppress the occurrence of polarization reversal.

Preferred Embodiment 3

Next, an acoustic wave device **1***b* according to Preferred Embodiment 3 of the present invention will be described with reference to FIG. **5**. As for the acoustic wave device **1***b* according to Preferred Embodiment 3, the same or corresponding elements as those of the acoustic wave device **1** according to Preferred Embodiment 1 are denoted by the same reference signs, and description thereof will be omitted.

The acoustic wave device **1***b* according to Preferred Embodiment 3 is different from the acoustic wave device **1** according to Preferred Embodiment 1 in that neither of the high acoustic velocity film **3** and the low acoustic velocity film **4** of the acoustic wave device **1** according to Preferred Embodiment 1 are provided. That is, in the acoustic wave device **1***b* according to Preferred Embodiment 3, a piezoelectric layer **5** is provided directly on a first principal surface **21** of a support substrate **2**.

In the acoustic wave device **1***b* according to Preferred Embodiment 3, the support substrate **2** is a high acoustic velocity support substrate. The support substrate **2** includes, for example, at least one material selected from the group consisting of silicon, aluminum nitride, aluminum oxide, silicon carbide, silicon nitride, sapphire, lithium tantalate, lithium niobate, crystal, alumina, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond.

The acoustic wave device **1***b* according to Preferred Embodiment 3 includes the same or substantially the same stress relaxation layer **9** as that of the acoustic wave device **1** according to Preferred Embodiment 1, which makes it possible to suppress the occurrence of polarization reversal.

Preferred Embodiments 1 to 3 described above are merely examples of various preferred embodiments of the present invention. Preferred Embodiments 1 to 3 described above may be variously modified in accordance with design or the like as long as the advantageous effects of the present invention are achieved.

Each of the acoustic wave devices **1**, **1***a*, and **1***b* may include a stress relaxation layer that is separate from the stress relaxation layer **9** and is interposed between the first connection section **71** and the piezoelectric layer **5**. Each of the acoustic wave devices **1**, **1***a*, and **1***b* may include a stress relaxation layer that is separate from the stress relaxation layer **9** and is interposed between the third connection section **73** and the piezoelectric layer **5**.

The shape of the stress relaxation layer **9** in a plan view from the thickness direction D**0** of the support substrate **2** may be appropriately modified in accordance with the shape of the second connection section **72** in the plan view from the thickness direction D**0** of the support substrate **2**.

In each of the acoustic wave devices **1**, **1***a*, and **1***b*, the plurality of IDT electrodes **110** may be appropriately connected by a plurality of the connection sections (including the first connection section **71**, the second connection section **72**, and the third connection section **73**) to define a ladder filter or a longitudinally coupled filter.

Each of the plurality of IDT electrodes **110** is a normal IDT electrode, but is not limited thereto, and may be an IDT electrode to which apodization weighting is applied or an inclined IDT electrode, for example. In the IDT electrode to which apodization weighting is applied, the overlap width increases from one end portion toward the center in the propagation direction of the acoustic wave, and decreases from the center toward the other end portion in the propagation direction of the acoustic wave.

The acoustic wave device **1** may further include a first reflector disposed on each of one side and the other side of the first IDT electrode **111** in the first direction D**1**, and a second reflector disposed on each of one side and the other side of the second IDT electrode **112** in the second direction D**2**. The first reflector reflects the acoustic wave whose acoustic wave propagation direction is the first direction D**1**. The second reflector reflects the acoustic wave whose acoustic wave propagation direction is the second direction D**2**.

The first and second reflectors are provided directly on the first principal surface **51** of the piezoelectric layer **5**, for example. Each of the first reflector and the second reflector is, for example, a short-circuit grating, but is not limited thereto, and may be an open grating or a positive/negative reflection type grating, for example.

Each of the first reflector and the second reflector is electrically conductive. The material of the first and second reflectors is, for example, Al, Cu, Pt, Au, Ag, Ti, Ni, Cr, Mo, W, Ta, Mg, Fe, or an alloy mainly including any of these metals. Each of the first and second reflectors may have a structure in which a plurality of metal films made of these metals or alloys is laminated. Each of the first and second reflectors includes a laminated film including, for example, the first metal film made of a Ti film formed on the piezoelectric layer **5** and the second metal film made of an Al film formed on the first metal film.

The following preferred embodiments of the present invention are disclosed herein.

An acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention includes the support substrate (**2**), the piezoelectric layer (**5**), the plurality of first electrode fingers (**61**) and the plurality of second electrode fingers (**62**), the plurality of third electrode fingers (**63**) and the plurality of fourth electrode fingers (**64**), the first busbar (**81**), the connection section (the second connection section **72**), and the fourth busbar (**84**). The plurality of first electrode fingers (**61**) and the plurality of second electrode fingers (**62**) are provided on the piezoelectric layer (**5**). The plurality of first electrode fingers (**61**) and the plurality of second electrode fingers (**62**) are spaced apart from each other in the first direction D**1** intersecting the thickness direction (D**0**) of the support substrate (**2**). The plurality of third electrode fingers (**63**) and the plurality of fourth electrode fingers (**64**) are provided on the piezoelectric layer (**5**). The plurality of third electrode fingers (**63**) and the plurality of fourth electrode fingers (**64**) are spaced apart from each other in the second direction (D**2**) intersecting the thickness direction (D**0**) of the support substrate (**2**). The first busbar (**81**) is provided on the piezoelectric layer (**5**) and is connected to the one end (**611**) of each of the plurality of first electrode fingers (**61**). The connection section (the second connection section **72**) includes the second busbar (**82**) and the third busbar (**83**). The second busbar (**82**) is provided on the piezoelectric layer (**5**) and is connected to the one end (**621**) of each of the plurality of second electrode fingers (**62**). The third busbar (**83**) is provided on the piezoelectric layer (**5**) and is connected to the one end (**631**) of each of the plurality of third electrode fingers (**63**). The fourth busbar (**84**) is provided on the piezoelectric layer (**5**) and is connected to the one end (**641**) of each of the plurality of fourth electrode fingers (**64**). The acoustic wave device (**1**; **1**a; **1**b) further includes the stress relaxation layer (**9**). The stress relaxation layer (**9**) is provided between the connection section (**72**) and the piezoelectric layer (**5**). The second busbar (**82**) faces the other end (**612**) of each of the plurality of first electrode fingers (**61**). The third busbar (**83**) faces the other end (**642**) of each of the plurality of fourth electrode fingers (**64**). The stress relaxation layer (**9**) does not extend to any of the gap (**102**) between each of the plurality of first electrode fingers (**61**) and the second busbar (**82**) and the gap (**103**) between each of the plurality of fourth electrode fingers (**64**) and the third busbar (**83**) in a plan view from the thickness direction (D**0**) of the support substrate (**2**).

The acoustic wave device (**1**; **1**a; **1**b) according to the above-described preferred embodiment may reduce or prevent the occurrence of polarization reversal.

In the above-described acoustic wave device (**1**; **1**a; **1**b), because the stress relaxation layer (**9**) does not extend to any of the gap (**102**) between each of the plurality of first electrode fingers (**61**) and the second busbar (**82**) and the gap (**103**) between each of the plurality of fourth electrode fingers (**64**) and the third busbar (**83**) in the plan view from the thickness direction (D**0**) of the support substrate (**2**), excitation characteristics of the acoustic wave device (**1**; **1**a; **1**b) are unlikely to be degraded.

In an acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention, the stress relaxation layer (**9**) includes the first projection (**93**) and the second projection (**94**). The first projection (**93**) projects from the first end **723** in the width direction (D**3**) of the connection section (the second connection section **72**) in the plan view from the thickness direction (D**0**) of the support substrate (**2**). The second projection (**94**) projects from the second end (**724**) in the width direction (D**3**) of the connection section (the second connection section **72**) in the plan view from the thickness direction (D**0**) of the support substrate (**2**).

In the above-described acoustic wave device (**1**; **1**a; **1**b), a margin may be obtained for the variation in the position of the stress relaxation layer (**9**) in the width direction (D**3**) of the connection section (the second connection section **72**).

In an acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention, the connection section (the second connection section **72**) includes the first connection end portion (**721**) including the second busbar (**82**) and the second connection end portion (**722**) including the third busbar (**83**). In the connection section (the second connection section **72**), the width (H**1**) of the first connection end portion (**721**) in the first direction (D**1**) is equal to or larger than the first length (L**1**), which is a length in the first direction (D**1**) of the overlap region (**121**) of the plurality of first electrode fingers (**61**) and the plurality of second electrode fingers (**62**). In the connection section (the second connection section **72**), the width (H**2**) of the second connection end portion (**722**) in the second direction (D**2**) is equal to or larger than the second length (L**2**), which is a length in the second direction (D**2**) of the overlap region (**122**) of the plurality of third electrode fingers (**63**) and the plurality of fourth electrode fingers (**64**).

In the above-described acoustic wave device (**1**; **1**a; **1**b), the resistance of the connection section (the second connection section **72**) may be lowered, and the loss may be reduced.

In an acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention, in the connection section (the second connection section **72**), the width (H**5**) in the portion (**725**) between the first connection end portion (**721**) and the second connection end portion (**722**) is not smaller than any of the first length (L**1**) and the second length (L**2**).

In the above-described acoustic wave device (**1**; **1**a; **1**b), the resistance of the connection section (the second connection section **72**) may be further lowered, and the loss may be reduced.

In an acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention, the stress relaxation layer (**9**) is one piece between the plurality of second electrode fingers (**62**) and the plurality of third electrode fingers (**63**).

In the above-described acoustic wave device (**1**; **1**a; **1**b), stresses applied to regions overlapping the gaps (**102** and **103**) in the piezoelectric layer (**5**) may be further relaxed.

In an acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention, the connection section (the second connection section **72**) is integrally provided with the plurality of second electrode fingers (**62**) and the plurality of third electrode fingers (**63**).

In the above-described acoustic wave device (**1**; **1**a; **1**b) preferred embodiment of the present invention, it is possible to reduce or prevent the degradation in characteristics as compared with a case where there is a contact interface between the connection section (the second connection section **72**), and the plurality of second electrode fingers (**62**) and the plurality of third electrode fingers (**63**).

In an acoustic wave device (**1**; **1**a; **1**b) according to a preferred embodiment of the present invention, the connection section (the second connection section **72**) includes the first layer (**72**A) and the second layer (**72**B). The first layer (**72**A) is integrally provided with the plurality of second electrode fingers (**62**) and the plurality of third electrode fingers (**63**). The second layer (**72**B) is formed on the opposite side of the first layer **72**A to the piezoelectric layer (**5**).

In the above-described acoustic wave device (**1**; **1***a*; **1***b*), the resistance of the connection section (the second connection section **72**) may be lowered, and the loss may be reduced.

In an acoustic wave device (**1**; **1***a*; **1***b*) according to a preferred embodiment of the present invention, the distance (L**13**) between the end (**91**) of the stress relaxation layer (**9**) on the plurality of second electrode fingers (**62**) side and the plurality of first electrode fingers (**61**) is longer than the distance (L**11**) between the end (**72**A**1**) of the first layer (**72**A) on the plurality of second electrode fingers (**62**) side and the plurality of first electrode fingers (**61**) in a plan view from the thickness direction (D**0**) of the support substrate (**2**). In the plan view from the thickness direction (D**0**) of the support substrate (**2**), the distance (L**23**) between the end (**92**) of the stress relaxation layer (**9**) on the plurality of third electrode fingers (**63**) side and the plurality of fourth electrode fingers (**64**) is longer than the distance (L**21**) between the end (**72**A**2**) of the first layer (**72**A) on the plurality of third electrode fingers (**63**) side and the plurality of fourth electrode fingers (**64**).

In the above-described acoustic wave device (**1**; **1***a*; **1***b*), a larger margin may be obtained for the variation in the position of the stress relaxation layer (**9**).

In an acoustic wave device (**1**; **1***a*; **1***b*) according to a preferred embodiment of the present invention, the distance (L**13**) between the end (**91**) of the stress relaxation layer (**9**) on the plurality of second electrode fingers (**62**) side and the plurality of first electrode fingers (**61**) is longer than the distance (L**12**) between the end (**72**B**1**) of the second layer (**72**B) on the plurality of second electrode fingers (**62**) side and the plurality of first electrode fingers (**61**) in a plan view from the thickness direction (D**0**) of the support substrate (**2**). In the plan view from the thickness direction (D**0**) of the support substrate (**2**), the distance (L**23**) between the end (**92**) of the stress relaxation layer (**9**) on the plurality of third electrode fingers (**63**) side and the plurality of fourth electrode fingers (**64**) is longer than the distance (L**22**) between the end (**72**B**2**) of the second layer (**72**B) on the plurality of third electrode fingers (**63**) side and the plurality of fourth electrode fingers (**64**).

In the above-described acoustic wave device (**1**; **1***a*; **1***b*), a larger margin may be obtained for the variation in the position of the stress relaxation layer (**9**).

In an acoustic wave device (**1**; **1***a*) according to a preferred embodiment of the present invention, the connection section (the second connection section **72**) does not include a pad electrode.

In the above-described acoustic wave device (**1**; **1***a*), the effect of a stress applied to a pad electrode via a bump connected to the pad electrode may be reduced or prevented.

An acoustic wave device (**1**; **1***a*) according to a preferred embodiment of the present invention further includes the low acoustic velocity film (**4**). The low acoustic velocity film (**4**) is provided between the support substrate (**2**) and the piezoelectric layer (**5**). The piezoelectric layer (**5**) includes at least one material selected from the group consisting of lithium tantalate, lithium niobate, zinc oxide, aluminum nitride, and PZT. The low acoustic velocity film (**4**) includes at least one material selected from the group consisting of silicon oxide, glass, silicon oxynitride, tantalum oxide, and a compound obtained by adding fluorine, carbon, or boron to silicon oxide.

The above-described acoustic wave device (**1**; **1***a*) may reduce the loss and increase the Q value as compared with a case where the low acoustic velocity film (**4**) is not provided.

An acoustic wave device (**1**) according to a preferred embodiment of the present invention further includes the low acoustic velocity film (**4**) and the high acoustic velocity film (**3**). The low acoustic velocity film (**4**) is provided between the support substrate (**2**) and the piezoelectric layer (**5**). The high acoustic velocity film (**3**) is provided between the support substrate (**2**) and the low acoustic velocity film (**4**). The piezoelectric layer (**5**) includes at least one material selected from the group consisting of lithium tantalate, lithium niobate, zinc oxide, aluminum nitride, and PZT. The low acoustic velocity film (**4**) includes at least one material selected from the group consisting of silicon oxide, glass, silicon oxynitride, tantalum oxide, and a compound obtained by adding fluorine, carbon, or boron to silicon oxide. The high acoustic velocity film (**3**) includes at least one material selected from the group consisting of diamond-like carbon, aluminum nitride, aluminum oxide, silicon carbide, silicon nitride, silicon, sapphire, lithium tantalate, lithium niobate, crystal, alumina, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond.

In the above-described acoustic wave device (**1**), it is possible to reduce or prevent the leakage of the acoustic wave to the support substrate (**2**) and increase the Q value.

In an acoustic wave device (**1***b*) according to a preferred embodiment of the present invention, the piezoelectric layer (**5**) includes at least one material selected from the group consisting of lithium tantalate, lithium niobate, zinc oxide, aluminum nitride, and PZT. The support substrate (**2**) includes at least one material selected from the group consisting of silicon, aluminum nitride, aluminum oxide, silicon carbide, silicon nitride, sapphire, lithium tantalate, lithium niobate, crystal, alumina, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond.

In the above-described acoustic wave device (**1***b*), it is possible to reduce or prevent the leakage of the acoustic wave to the support substrate (**2**) and increase the Q value.

In an acoustic wave device (**1**; **1***a*; **1***b*) according to a preferred embodiment of the present invention, the stress relaxation layer (**9**) includes at least one material selected from the group consisting of silicon oxide, polyimide, hafnium oxide, niobium oxide, tantalum oxide, tungsten oxide, and cerium oxide.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. An acoustic wave device, comprising:

a support substrate;

a piezoelectric layer on the support substrate;

a plurality of first electrode fingers and a plurality of second electrode fingers on the piezoelectric layer and spaced apart from each other in a first direction intersecting a thickness direction of the support substrate;

a plurality of third electrode fingers and a plurality of fourth electrode fingers on the piezoelectric layer and spaced apart from each other in a second direction intersecting the thickness direction of the support substrate;

a first busbar on the piezoelectric layer and connected to one end of each of the plurality of first electrode fingers;

a connection section including a second busbar on the piezoelectric layer and connected to one end of each of the plurality of second electrode fingers, and a third busbar on the piezoelectric layer and connected to one end of each of the plurality of third electrode fingers;

a fourth busbar on the piezoelectric layer and connected to one end of each of the plurality of fourth electrode fingers; and

a stress relaxation layer between the connection section and the piezoelectric layer; wherein

the second busbar faces another end of each of the plurality of first electrode fingers;

the third busbar faces another end of each of the plurality of fourth electrode fingers; and

the stress relaxation layer does not extend to either of a gap between the plurality of first electrode fingers and the second busbar or a gap between the plurality of fourth electrode fingers and the third busbar in a plan view from the thickness direction of the support substrate.

2. The acoustic wave device according to claim **1**, wherein the stress relaxation layer includes:

a first projection projecting from a first end in a width direction of the connection section in the plan view from the thickness direction of the support substrate; and

a second projection projecting from a second end in the width direction of the connection section in the plan view from the thickness direction of the support substrate.

3. The acoustic wave device according to claim **1**, wherein the connection section includes a first connection end portion including the second busbar, and a second connection end portion including the third busbar; and

in the connection section, a width of the first connection end portion in the first direction is equal to or larger than a first length, which is a length in the first direction of an overlap region of the plurality of first electrode fingers and the plurality of second electrode fingers, and a width of the second connection end portion in the second direction is equal to or larger than a second length, which is a length in the second direction of an overlap region of the plurality of third electrode fingers and the plurality of fourth electrode fingers.

4. The acoustic wave device according to claim **3**, wherein a width in a portion between the first connection end portion and the second connection end portion is not smaller than either of the first length or the second length.

5. The acoustic wave device according to claim **1**, wherein the stress relaxation layer is a single piece between the plurality of second electrode fingers and the plurality of third electrode fingers.

6. The acoustic wave device according to claim **1**, wherein the connection section is integrally provided with the plurality of second electrode fingers and the plurality of third electrode fingers.

7. The acoustic wave device according to claim **1**, wherein the connection section includes a first layer integrally provided with the plurality of second electrode fingers and the plurality of third electrode fingers, and a second layer on an opposite side of the first layer to the piezoelectric layer.

8. The acoustic wave device according to claim **7**, wherein in a plan view from the thickness direction of the support substrate, a distance between an end of the stress relaxation layer on the plurality of second electrode fingers side and the plurality of first electrode fingers is longer than a distance between an end of the first layer on the plurality of second electrode fingers side and the plurality of first electrode fingers, and a distance between an end of the stress relaxation layer on the plurality of third electrode fingers side and the plurality of fourth electrode fingers is longer than a distance between an end of the first layer on the plurality of third electrode fingers side and the plurality of fourth electrode fingers.

9. The acoustic wave device according to claim **7**, wherein in the plan view from the thickness direction of the support substrate, a distance between an end of the stress relaxation layer on the plurality of second electrode fingers side and the plurality of first electrode fingers is longer than a distance between an end of the second layer on the plurality of second electrode fingers side and the plurality of first electrode fingers, and a distance between an end of the stress relaxation layer on the plurality of third electrode fingers side and the plurality of fourth electrode fingers is longer than a distance between an end of the second layer on the plurality of third electrode fingers side and the plurality of fourth electrode fingers.

10. The acoustic wave device according to claim **1**, wherein the connection section does not include a pad electrode.

11. The acoustic wave device according to claim **1**, further comprising:

a low acoustic velocity film between the support substrate and the piezoelectric layer;

the piezoelectric layer includes at least one of lithium tantalate, lithium niobate, zinc oxide, aluminum nitride, and PZT; and

the low acoustic velocity film includes at least one of silicon oxide, glass, silicon oxynitride, tantalum oxide, and a compound obtained by adding fluorine, carbon, or boron to silicon oxide.

12. The acoustic wave device according to claim **11**, wherein the stress relaxation layer includes at least one of silicon oxide, polyimide, hafnium oxide, niobium oxide, tantalum oxide, tungsten oxide, and cerium oxide.

13. The acoustic wave device according to claim **11**, wherein a thickness of the low acoustic velocity film is about 670 nm.

14. The acoustic wave device according to claim **1**, further comprising:

a low acoustic velocity film between the support substrate and the piezoelectric layer; and

a high acoustic velocity film between the support substrate and the low acoustic velocity film; wherein

the piezoelectric layer includes at least one of lithium tantalate, lithium niobate, zinc oxide, aluminum nitride, and PZT;

the low acoustic velocity film includes at least one of silicon oxide, glass, silicon oxynitride, tantalum oxide, and a compound obtained by adding fluorine, carbon, or boron to silicon oxide; and

the high acoustic velocity film includes at least one of diamond-like carbon, aluminum nitride, aluminum oxide, silicon carbide, silicon nitride, silicon, sapphire, lithium tantalate, lithium niobate, crystal, alumina, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond.

15. The acoustic wave device according to claim **14**, wherein a thickness of the low acoustic velocity film is about 670 nm.

16. The acoustic wave device according to claim **14**, wherein a thickness of the high acoustic velocity film is about 200 nm, about 300 nm, or about 400 nm.

17. The acoustic wave device according to claim **1**, wherein

the piezoelectric layer includes at least one of lithium tantalate, lithium niobate, zinc oxide, aluminum nitride, and PZT; and

the support substrate includes at least one of silicon, aluminum nitride, aluminum oxide, silicon carbide, silicon nitride, sapphire, lithium tantalate, lithium niobate, crystal, alumina, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond.

18. The acoustic wave device according to claim **1**, wherein the stress relaxation layer has a rectangular or substantially rectangular shape.

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