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ACOUSTIC WAVE DEVICE

Abstract

An acoustic wave device includes a piezoelectric substrate including a piezoelectric layer and a support substrate stacked on a second main surface side of the piezoelectric layer, a first electrode layer between the support substrate and the piezoelectric layer and not connected to a signal potential, and an IDT electrode on a first main surface of the piezoelectric layer and including electrode fingers. A region where adjacent electrode fingers overlap each other is a crossing region. The first electrode layer is provided at a position overlapping the crossing region in plan view. The piezoelectric substrate includes a first formation region overlapping the crossing region and the first electrode layer and a first non-formation region overlapping the crossing region and not overlapping the first electrode layer, and the first non-formation region overlaps a portion between the adjacent electrode fingers.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This application claims the benefit of priority to Japanese Patent Application No. 2022-181810 filed on Nov. 14, 2022 and is a Continuation Application of PCT Application No. PCT/JP2023/037687 filed on Oct. 18, 2023. The entire contents of each application are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION
1. Field of the Invention
[0002] The present invention relates to acoustic wave devices.
2. Description of the Related Art
[0003] To date, acoustic wave devices have been widely used in filters of mobile phones and the like. Japanese Unexamined Patent Application Publication No. 2002-151996 discloses an example of a surface acoustic wave element as an acoustic wave device. In the surface acoustic wave element, a metal layer is formed on a rigid substrate. A Zno layer is provided on the rigid substrate and on the metal layer. An IDT (Interdigital Transducer) is provided on the Zno layer. A pair of grating reflectors are provided on both sides of the IDT. Moreover, a wiring electrode is provided on the Zno layer so as to face the metal layer.
[0004] However, a substrate corresponding to the rigid substrate described in Japanese Unexamined Patent Application Publication No. 2002-151996 may have a defect. A fault may occur in an element including a defective substrate, and production efficiency may decrease.
SUMMARY OF THE INVENTION
[0005] Example embodiments of the present invention provide acoustic wave devices each of which are able to be identified if the acoustic wave devices include a defective substrate and that are each able to reduce or prevent a fault in a product.
[0006] An acoustic wave device according to an example embodiment of the present invention includes a piezoelectric substrate including a piezoelectric layer including a first main surface and a second main surface facing each other and a support substrate stacked on the second main surface side of the piezoelectric layer, at least one first electrode layer between the support substrate and the piezoelectric layer and not connected to a signal potential, and an IDT electrode on the first main surface of the piezoelectric layer and including a plurality of electrode fingers. When an electrode finger extending direction is defined as a direction in which the plurality of electrode fingers extend and the IDT electrode is seen from a direction orthogonal or substantially orthogonal to the electrode finger extending direction, a region where electrode fingers of the plurality of electrode fingers that are adjacent to each other overlap is a crossing region. The first electrode layer is provided at least at a position that overlaps the crossing region in plan view. The piezoelectric substrate includes a first formation region that overlaps the crossing region and overlaps the first electrode layer in plan view and a first non-formation region that overlaps the crossing region and does not overlap the first electrode layer in plan view, and the first non-formation region overlaps in plan view at least one of portions between the electrode fingers that are adjacent to each other.
[0007] Acoustic wave devices according to example embodiments of the present invention are each

able to be identified if the acoustic wave devices include a defective substrate and are each able to reduce or prevent a fault in a product.
[0008] 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 example embodiments with reference to the attached drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0009] FIG. **1** is a schematic plan view of an acoustic wave device according to a first example embodiment of the present invention.
[0010] FIG. **2** is a schematic sectional view taken along line I-I in FIG. **1**.
[0011] FIG. **3** is a schematic plan view illustrating each region in the first example embodiment of the present invention.
[0012] FIG. **4** is a schematic plan view of an acoustic wave device according to a comparative example.
[0013] FIG. **5** is a schematic plan view of an acoustic wave device according to a modification of the first example embodiment of the present invention.
[0014] FIG. **6** is a schematic plan view of an acoustic wave device according to a second example embodiment of the present invention.
[0015] FIG. **7** is a schematic plan view illustrating each region in the second example embodiment of the present invention.
[0016] FIG. **8** is a schematic bottom view illustrating the configuration of a first electrode layer and a second electrode layer in a third example embodiment of the present invention.
[0017] FIG. **9** is a schematic bottom view illustrating the configuration of a first electrode layer and a second electrode layer in a fourth example embodiment of the present invention.
[0018] FIG. **10** is a schematic front sectional view of an acoustic wave device according to a fifth example embodiment of the present invention.
[0019] FIG. **11** is a circuit diagram of a filter device according to a sixth example embodiment of the present invention.
[0020] FIG. **12** illustrates the impedance frequency characteristics of an acoustic wave resonator including a first electrode layer and a second electrode layer and an acoustic wave resonator not including a first electrode layer and a second electrode layer in the sixth example embodiment of the present invention.
[0021] FIG. **13** is a schematic plan view of an acoustic wave device according to a seventh example embodiment of the present invention.
[0022] FIG. **14** is a schematic plan view illustrating each region near a portion overlapping a first electrode layer in plan view and first imaginary lines in the seventh example embodiment of the present invention.
[0023] FIG. **15** is a schematic plan view illustrating each region near a portion overlapping the first electrode layer in plan view, second imaginary lines, and a third imaginary line in the seventh example embodiment of the present invention.
[0024] FIG. **16** is a schematic plan view illustrating each region near a portion overlapping a first electrode layer in plan view, a third imaginary line, and some uniform portions in a first modification of the seventh example embodiment of the present invention.
[0025] FIG. **17** is a schematic plan view illustrating each region near a portion overlapping a first electrode layer in plan view, a third imaginary line, and some uniform portions in a second modification of the seventh example embodiment of the present invention.
[0026] FIG. **18** is a schematic plan view of an acoustic wave device according to an eighth example

embodiment of the present invention.
[0027] FIG. **19** is a schematic sectional view taken along line II-II in FIG. **18**.
[0028] FIG. **20** is a schematic plan view of a filter device according to a ninth example embodiment of the present invention.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

[0029] Hereafter, the present invention will be clarified by describing example embodiments of the present invention with reference to the drawings.
[0030] Each example embodiment of the present invention described in the present specification is an example, and it is possible to replace or combine some elements or features between different example embodiments.
[0031] FIG. **1** is a schematic plan view of an acoustic wave device according to a first example embodiment of the present invention. FIG. **2** is a schematic sectional view taken along line I-I in FIG. **1**. In FIG. **2**, the boundaries between a first formation region, a first non-formation region, a second formation region, and a second non-formation region described below are indicated by broken lines, and these regions are shown by different hatching patterns. The same applies to schematic sectional views other than FIG. **2**.
[0032] An acoustic wave device **1** illustrated in FIGS. **1** and **2** is an acoustic wave resonator. The acoustic wave device **1** is used, for example, in a band-pass filter, a multiplexer, a high-frequency front-end circuit, or the like. Products in which the acoustic wave device **1** is used are not limited to the above.
[0033] As illustrated in FIG. **2**, the acoustic wave device **1** includes a piezoelectric substrate **2**. The piezoelectric substrate **2** includes a support substrate **3**, an intermediate layer **4**, a dielectric layer **5**, and a piezoelectric layer **6**. That is, "piezoelectric substrate" refers to a substrate having piezoelectricity. The support substrate **3**, the intermediate layer **4**, the dielectric layer **5**, and the piezoelectric layer **6** are stacked in this order. The intermediate layer **4** is a multilayer body. To be specific, the intermediate layer **4** includes a first layer **4**A and a second layer **4**B. The first layer **4**A is provided on the support substrate **3**. The second layer **4**B is provided on the first layer **4**A. The second layer **4**B and the dielectric layer **5** are integrally made of the same material. In FIG. **2**, the boundary between the second layer **4**B and the dielectric layer **5** is shown by a two-dot chain line. However, the second layer **4**B and the dielectric layer **5** may be independently made of different materials. The intermediate layer **4** may be a single-layer dielectric film or the like.
[0034] The piezoelectric layer **6** includes a first main surface **6***a* and a second main surface **6***b*. The first main surface **6***a* and the second main surface **6***b* face each other. The dielectric layer **5**, the intermediate layer **4**, and the support substrate **3** are stacked on the second main surface **6***b* side, among the first main surface **6***a* side and the second main surface **6***b* side. It is sufficient that the piezoelectric substrate **2** includes at least the support substrate **3** and the piezoelectric layer **6**.
[0035] An IDT electrode **7** and a pair of reflectors **8**A and **8**B are provided on the first main surface **6***a* of the piezoelectric layer **6**. An acoustic wave is excited when an alternating-current voltage is applied to the IDT electrode **7**. The acoustic wave device **1** according to the present example embodiment is a surface acoustic wave resonator.
[0036] To be more specific, as illustrated in FIG. **1**, the IDT electrode **7** includes a first busbar **16**, a second busbar **17**, a plurality of first electrode fingers **18**, and a plurality of second electrode fingers **19**. The first busbar **16** and the second busbar **17** face each other. One end of each of the plurality of first electrode fingers **18** is connected to the first busbar **16**. One end of each of the plurality of second electrode fingers **19** is connected to the second busbar **17**. The plurality of first electrode fingers **18** and the plurality of second electrode fingers **19** are interdigitated with each other. The first electrode fingers **18** and the second electrode fingers **19** are connected to different potentials. Hereafter, the first electrode fingers **18** and the second electrode fingers **19** may be simply referred to as electrode fingers.
[0037] When an electrode finger extending direction is defined as a direction in which a plurality of

electrode fingers extend, in the present example embodiment, the electrode finger extending direction is orthogonal or substantially orthogonal to an acoustic wave propagation direction. A crossing region A is a region where adjacent electrode fingers overlap when the IDT electrode **7** is seen from a direction orthogonal or substantially orthogonal to the electrode finger extending direction, that is, the acoustic wave propagation direction. An acoustic wave is excited in the crossing region A. In the present example embodiment, the acoustic wave propagation direction is orthogonal or substantially orthogonal to the electrode finger extending direction.

[0038] The reflector **8**A and the reflector **8**B face each other with the IDT electrode **7** therebetween in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. The reflector **8**A and the reflector **8**B each include a plurality of reflector electrode fingers **8***a*. A reflector crossing region B of each reflector is a region where adjacent reflector electrode fingers **8***a* overlap when each reflector is seen from the direction orthogonal or substantially orthogonal to the electrode finger extending direction.

[0039] As illustrated in FIG. **2**, a first electrode layer **13**, a second electrode layer **14**A, and a second electrode layer **14**B are provided between the support substrate **3** and the piezoelectric layer **6**. To be specific, the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are provided on the intermediate layer **4** side of the dielectric layer **5**. The first electrode layer **13** and each second electrode layer are embedded in the second layer **4**B of the intermediate layer **4**. Thus, a portion of the intermediate layer **4** is positioned between the support substrate **3** and both the first electrode layer **13** and each second electrode layer.

[0040] In the present example embodiment, the intermediate layer **4** and the dielectric layer **5** are provided between the support substrate **3** and the piezoelectric layer **6**. Thus, it is possible to increase the closeness of contact between the support substrate **3** and the piezoelectric layer **6**. However, the dielectric layer **5** may be omitted, and the support substrate **3** and the piezoelectric layer **6** may be joined by the intermediate layer **4**. In this case, the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B may be provided directly on the second main surface **6***b* of the piezoelectric layer **6**. Alternatively, the support substrate **3** and the piezoelectric layer **6** may be joined directly.

[0041] As illustrated in FIG. **1**, the first electrode layer **13** overlaps the crossing region A of the IDT electrode **7** in plan view. The second electrode layer **14**A, which is one of the two second electrode layers, overlaps the reflector crossing region B of the reflector **8**A in plan view. The second electrode layers **14**B, which is the other second electrode layer, overlaps the reflector crossing region B of the reflector **8**B in plan view. In the present specification, “plan view” refers to a view of an acoustic wave device seen from the upward direction in FIG. **2**. In FIG. **2**, for example, the piezoelectric layer **6** side is the upper side, among the piezoelectric layer **6** side and the support substrate **3** side.

[0042] The first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are floating electrodes. The term “floating electrode” refers to an electrode that is not electrically connected to either of a signal potential and a reference potential. The first electrode layer **13** and each second electrode layer may be connected to a reference potential. It is sufficient that the first electrode layer **13** and each second electrode layer are not connected to a signal potential.

[0043] As illustrated in FIG. **1**, the first electrode layer **13** includes a plurality of through-holes **13***a* and a plurality of cutout portions **13***b*. In the present specification, the expression “a through-hole is provided in an electrode layer” means that the entirety or substantially the entirety of a portion where the electrode layer is not provided is surrounded by a portion where the electrode layer is provided. That is, the through-hole is not positioned at an outer peripheral edge of the electrode layer. The expression “a cutout portion is provided in an electrode layer” means that a portion where the electrode layer is not provided includes a portion that is not surrounded by a portion where the electrode layer is provided. That is, the cutout portion is positioned on an outer

peripheral edge of the electrode layer. In the present specification, “outer peripheral edge” refers to an outer peripheral edge when seen in plan view.
[0044] As with the first electrode layer **13**, the second electrode layer **14**A and the second electrode layer **14**B each include a plurality of through-holes **14***a* and a plurality of cutout portions **14***b*. However, the configuration of the second electrode layer **14**A and the second electrode layer **14**B is not particularly limited. The second electrode layer **14**A and the second electrode layer **14**B may be omitted.
[0045] FIG. **3** is a schematic plan view illustrating each region in the first example embodiment.
[0046] The piezoelectric substrate **2** includes a first formation region C and a first non-formation region D. To be specific, the first formation region C is a region that overlaps the crossing region A and overlaps the first electrode layer **13** in plan view. That is, the first formation region C is a region of the piezoelectric substrate **2** that overlaps in plan view a portion where the first electrode layer **13** is provided. The first non-formation region D is a region that overlaps the crossing region A and does not overlap the first electrode layer **13** in plan view. That is, the first non-formation region D is a region of the piezoelectric substrate **2** that overlaps in plan view a portion where the first electrode layer **13** is not provided. The piezoelectric substrate **2** of the acoustic wave device **1** includes a plurality of first non-formation regions D. To be more specific, some first non-formation regions D among all of the first non-formation regions D are regions of the piezoelectric substrate **2** each of which overlaps a corresponding one of the through-holes **13***a* in plan view. The other first non-formation regions D are regions of the piezoelectric substrate **2** each of which overlaps a corresponding one of the cutout portions **13***b* in plan view.
[0047] A feature of the present example embodiment is that the piezoelectric substrate **2** includes the first formation region C and the first non-formation region D, and the first non-formation region D overlaps in plan view at least one of the portions between adjacent electrode fingers. Thus, the acoustic wave device **1** can be identified if the acoustic wave device **1** includes a piezoelectric substrate **2** with a defect. Thus, it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device **1**. The details of this will be described below by comparing the present example embodiment with a comparative example. Hereafter, unless otherwise noted, “a portion between electrode fingers” refers to a portion between adjacent electrode fingers.
[0048] As illustrated in FIG. **4**, the comparative example differs from the first example embodiment in that an electrode layer **103** does not include a through-hole and a cutout portion and that the electrode layer **103** overlaps the IDT electrode **7** and a pair of reflectors in plan view.
[0049] As described above, the acoustic wave device **1** according to the first example embodiment illustrated in FIG. **2** is used, for example, in a band-pass filter, a multiplexer, a high-frequency front-end circuit, or the like. Therefore, the above products, each including the acoustic wave device **1**, are manufactured with processes after a process of manufacturing the acoustic wave device **1**.
[0050] Here, in the process of manufacturing the acoustic wave device **1**, a defect may occur on the support substrate **3** side of the piezoelectric substrate **2**. When the support substrate **3**, the intermediate layer **4**, and the dielectric layer **5** are the layers of the piezoelectric substrate **2**, examples of the defect include delamination between any of the layers, entry of a foreign substance into a space between any of the layers, and the occurrence of a flaw in any of the layers.
[0051] The same applies to an acoustic wave device **101** according to the comparative example illustrated in FIG. **4**. However, in the acoustic wave device **101** according to the comparative example, a region where the electrode layer **103** is provided overlaps the crossing region when seen in plan view. Light such as visible light used to observe does not easily pass through the electrode layer **103**, which is made of a metal. Therefore, it is difficult to identify a defect on the support substrate **3** side when the piezoelectric substrate **2** is seen from the piezoelectric layer **6** side. Thus, it is difficult to sort out an acoustic wave device **101** including a defect in the piezoelectric

substrate **2**. As a result, for example, a fault related to reliability may occur easily in a product including an acoustic wave device **101**. That is, yield may decrease.

[0052] In contrast, in the first example embodiment illustrated in FIG. **2**, the piezoelectric substrate **2** includes the first non-formation region D, which overlaps in plan view a portion where the first electrode layer **13** is not provided. Moreover, the first non-formation region D overlaps in plan view at least one of the portions between electrode fingers. Here, the piezoelectric layer **6**, the dielectric layer **5**, and the intermediate layer **4** are each made of, for example, a piezoelectric material or a dielectric and each have a small thickness. Therefore, light such as visible light used to observe sufficiently passes through the piezoelectric layer **6**, the dielectric layer **5**, and the intermediate layer **4**. Thus, it is possible to easily observe the support substrate **3** side from a portion where the first non-formation region D overlaps in plan view a portion between electrode fingers. Thus, it is possible to identify an acoustic wave device **1** including a defect in the piezoelectric substrate **2**. Thus, it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device **1**. Accordingly, it is possible to increase the yield of the product, and it is possible to increase production efficiency.

[0053] As described above, an acoustic wave is excited in the crossing region A. Therefore, if a defect that affects the crossing region A occurs, the electric characteristics of the acoustic wave device **1** tend to become unstable. On the other hand, the first non-formation region D overlaps the crossing region A in plan view. Thus, it is easy to identify an acoustic wave device **1** including a defect that is likely to affect the crossing region A. Accordingly, it is possible to more reliably increase the production efficiency of a product including an acoustic wave device **1**.

[0054] In addition, the first electrode layer **13** and the IDT electrode **7** face each other with the piezoelectric layer **6** therebetween. Thus, it is possible to increase the electrostatic capacitance of the acoustic wave device **1**. Thus, it is possible to reduce the size of the acoustic wave device **1** while obtaining a desirable electrostatic capacitance.

[0055] Hereafter, further details of the configuration of the first example embodiment will be described. First, examples of the material of each layer in the piezoelectric substrate **2** will be described. In the present specification, the meaning of an expression “a member is made of a material” includes a meaning that the material includes a very small amount of impurity that does not degrade the electric characteristics of an acoustic wave device. In the present specification, “main component” refers to a component whose content ratio is greater than about 50 wt %. The material of the main component may exist in a single-crystal state, a polycrystal state, an amorphous state, or a state in which these states are mixed.

[0056] In the first example embodiment, the support substrate **3** of the piezoelectric substrate **2** is made of silicon, for example. The azimuth angle of the main surface of the support substrate **3** is (**111**), for example. However, the azimuth angle and the material of the support substrate **3** are not limited to the above. Examples of the material of the support substrate **3** include piezoelectric materials such as aluminum nitride, lithium tantalate, lithium niobate, or quartz, ceramics such as alumina, sapphire, magnesia, silicon nitride, silicon carbide, zirconia, cordierite, mullite, steatite, forsterite, spinel, or sialon, dielectrics such as aluminum oxide, silicon oxynitride, DLC (diamond-like carbon), or diamond; semiconductors such as silicon, or materials including any of the above materials as a main component. The spinel includes an aluminum compound including, for example, one or more elements of Mg, Fe, Zn, Mn, or the like, or oxygen. Examples of the spinel include, for example, MgAl.sub.2O.sub.4, FeAl.sub.2O.sub.4, ZnAl.sub.2O.sub.4, Of MnAl.sub.2O.sub.4.

[0057] In the first example embodiment, the first layer **4**A of the intermediate layer **4** is a high-acoustic-velocity film as a high-acoustic-velocity material layer. A high-acoustic-velocity material layer is a layer in which the acoustic velocity is relatively high. To be more specific, the acoustic velocity of a bulk wave that propagates in a high-acoustic-velocity material layer is higher than the acoustic velocity of an acoustic wave that propagates in the piezoelectric layer **6**. In the first

example embodiment, the first layer **4**A as a high-acoustic-velocity material layer is made of silicon nitride, for example. The material of a high-acoustic-velocity material layer is not limited to the above. Examples of the material include piezoelectric materials such as aluminum nitride, lithium tantalate, lithium niobate, or quartz, ceramics such as alumina, sapphire, magnesia, silicon nitride, silicon carbide, zirconia, cordierite, mullite, steatite, forsterite, spinel, or sialon, dielectrics such as aluminum oxide, silicon oxynitride, DLC (diamond-like carbon), or diamond, semiconductors such as silicon, and materials including any of the above materials as a main component. The spinel includes, for example, an aluminum compound including one or more elements of Mg, Fe, Zn, Mn, or the like, or oxygen. Examples of the spinel include MgAl.sub.2O.sub.4, FeAl.sub.2O.sub.4, ZnAl.sub.2O.sub.4, or MnAl.sub.2O.sub.4.
[0058] In the first example embodiment, the second layer **4**B of the intermediate layer **4** is a low-acoustic-velocity film. A low-acoustic-velocity film is a film in which the acoustic velocity is relatively low. To be more specific, the acoustic velocity of a bulk wave that propagates in a low-acoustic-velocity film is lower than the acoustic velocity of a bulk wave that propagates in the piezoelectric layer **6**. In the first example embodiment, the second layer **4**B as a low-acoustic-velocity film is made of silicon oxide, for example. However, the material of a low-acoustic-velocity film is not limited to the above. Examples of the material include dielectrics such as glass, silicon oxide, silicon oxynitride, lithium tantalum oxide, or chemical compounds in which fluorine, carbon, or boron is added to silicon oxide, or materials including any of the above materials as a main component. In the first example embodiment, the dielectric layer **5** is also a low-acoustic-velocity film the same as or similar to the second layer **4**B.
[0059] Examples of the material of the piezoelectric layer **6** include lithium niobate, lithium tantalate, zinc oxide, aluminum nitride, quartz, or PZT (lead zirconate titanate). Preferably, the material of the piezoelectric layer **6** is, for example, lithium niobate such as LiNbO.sub.3 or lithium tantalate such as LiTaO.sub.3.
[0060] In the piezoelectric substrate **2**, the first layer **4**A as a high-acoustic-velocity material layer, the second layer **4**B and the dielectric layer **5** as low-acoustic-velocity films, and the piezoelectric layer **6** are stacked in this order. Thus, it is possible to effectively confine the energy of an acoustic wave in the piezoelectric layer **6** side.
[0061] In the first example embodiment, the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are made of Ti, for example. However, the material the first electrode layer **13** and each second electrode layer is not limited to the above.
[0062] The IDT electrode **7**, the reflector **8**A, and the reflector **8**B each include a multilayer metal film. To be specific, in each of the IDT electrode **7**, the reflector **8**A, and the reflector **8**B, for example, a Ti layer, an Al layer, and a Ti layer are stacked in this order. However, the material of each of the IDT electrode **7** and each reflector is not limited to the above. The IDT electrode **7** and each reflector each may include a single-layer metal film.
[0063] Hereafter, examples of the design parameters of the acoustic wave device **1** according to the first example embodiment will be described. Here, λ denotes a wavelength that is determined by the electrode finger pitch of the IDT electrode **7**. The term “electrode finger pitch” refers to the center-to-center distance between adjacent electrode fingers that are connected to different potentials in the acoustic wave propagation direction. To be specific, λ=2p, where p is the electrode finger pitch.
[0064] IDT electrode **7**; layer configuration Ti layer/Al layer/Ti layer, total thickness about 0.2λ or less
[0065] Piezoelectric Layer **6**; material LiNbO.sub.3, thickness about 1λ or less
[0066] Dielectric Layer **5**; material SiO.sub.2, thickness about 0.2λ or less
[0067] First Electrode Layer **13**; material Ti, thickness about 0.1λ or less
[0068] Second Layer **4**B; material SiO.sub.2, thickness about 0.2λ or less
[0069] First Layer **4**A; material SiN, thickness about 0.5λ or less

[0070] Support Substrate **3**; material Si, azimuth angle (**111**)

[0071] For example, in the design parameters listed above, the material of the piezoelectric layer **6** may be LiTaO.sub.3. The thickness of each of the second electrode layer **14**A and the second electrode layer **14**B may be, for example, about 0.1λ or less, as with the first electrode layer **13**.

[0072] As illustrated in FIG. **3**, the piezoelectric substrate **2** includes a second formation region Ea, a second non-formation region Fa, a second formation region Eb, and a second non-formation region Fb. To be specific, the second formation region Ea is a region that overlaps the reflector crossing region B of the reflector **8**A and overlaps the second electrode layer **14**A in plan view. The second non-formation region Fa is a region that overlaps the reflector crossing region B of the reflector **8**A and does not overlap the second electrode layer **14**A in plan view. The second formation region Eb is a region that overlaps the reflector crossing region B of the reflector **8**B and overlaps the second electrode layer **14**B in plan view. The second non-formation region Fb is a region that overlaps the reflector crossing region B of the reflector **8**B and does not overlap the second electrode layer **14**B in plan view.

[0073] The piezoelectric substrate **2** of the acoustic wave device **1** includes a plurality of second non-formation regions Fa. To be more specific, some second non-formation regions Fa among all of the second non-formation regions Fa are regions of the piezoelectric substrate **2** each of which overlaps in plan view a corresponding one of the through-holes **14***a* provided in the second electrode layer **14**A. The other second non-formation regions Fa are regions of the piezoelectric substrate **2** each of which overlaps in plan view a corresponding one of the cutout portions **14***b* provided in the second electrode layer **14**A. Similarly, the piezoelectric substrate **2** includes a plurality of second non-formation regions Fb.

[0074] As illustrated in FIG. **2**, the plurality of second non-formation regions Fa each overlap in plan view one of the portions between adjacent reflector electrode fingers **8***a* of the reflector **8**A. Similarly, the plurality of second non-formation regions Fb each overlap in plan view one of the portions between adjacent reflector electrode fingers **8***a* of the reflector **8**B. Hereafter, unless otherwise noted, “the portions between the reflector electrode fingers **8***a*” refer to the portions between adjacent reflector electrode fingers **8***a*.

[0075] In the present example embodiment, the second electrode layer **14**A and the reflector **8**A face each other with the piezoelectric layer **6** therebetween. Similarly, the second electrode layer **14**B and the reflector **8**B face each other with the piezoelectric layer **6** therebetween. Thus, it is possible to effectively increase the electrostatic capacitance of the acoustic wave device **1**. Thus, it is possible to more reliably reduce the size of the acoustic wave device **1** while obtaining a desirable electrostatic capacitance.

[0076] In addition, it is possible to easily observe the support substrate **3** side from a portion where the second non-formation region Fa overlaps in plan view a portion of the reflector **8**A between the reflector electrode fingers **8***a*. Similarly, it is possible to easily observe the support substrate **3** side from a portion where the second non-formation region Fb overlaps in plan view a portion of the reflector **8**B between the reflector electrode fingers **8***a*. Thus, it is possible to more reliably identify an acoustic wave device **1** including a defect in the piezoelectric substrate **2**. Thus, it is possible to more reliably reduce or prevent the occurrence of a fault in a product including an acoustic wave device **1**.

[0077] As illustrated in FIG. **1**, in the present example embodiment, the IDT electrode **7** and each reflector are connected. To be specific, the first busbar **16** and the reflector **8**A are connected by a connection wiring line **9**. The first busbar **16** and the reflector **8**B are connected by another connection wiring line **9**. To be more specific, the first busbar **16**, each connection wiring line **9**, and each reflector are integrally provided. The first busbar **16**, each reflector, and each connection wiring line **9** may be independently provided from different materials, and the first busbar **16** and each reflector may be connected by a corresponding connection wiring line **9**. Alternatively, the first busbar **16** and each reflector need not be connected.

[0078] Hereafter, preferable configurations s in the first example embodiment will be described. It is preferable that the piezoelectric substrate **2** includes a plurality of first non-formation regions D. Thus, it is possible to easily observe the support substrate **3** side.
[0079] It is more preferable that at least some first non-formation regions D among all of the first non-formation regions D are arranged at a period that is an integer multiple of the electrode finger pitch of the IDT electrode **7** in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. In the first example embodiment, the plurality of through-holes **13***a* provided in the first electrode layer **13** are arranged at a period that is an integer multiple of the electrode finger pitch of the IDT electrode **7** in the direction orthogonal to the electrode finger extending direction. The plurality of cutout portions **13***b* provided in the first electrode layer **13** are also arranged at a period that is an integer multiple of the electrode finger pitch of the IDT electrode **7** in the direction orthogonal to the electrode finger extending direction. Thus, the plurality of first non-formation regions D are disposed as described above.
[0080] In this case, at least some portions between electrode fingers among all of the portions between electrode fingers each overlap a corresponding one of the first non-formation regions D in plan view. Thus, it is easy to observe the support substrate **3** side. In addition, the first electrode layer **13** has a periodic structure that matches the IDT electrode **7**. Thus, it is possible to improve the resonance characteristics of the acoustic wave device **1**. To be specific, for example, it is possible to increase the Q-value.
[0081] It is preferable that all of the portions between electrode fingers each overlap a corresponding one of the first non-formation regions D in plan view. It is more preferable that the first non-formation regions D are arranged at a period that is the same or substantially the same as the electrode finger pitch of the IDT electrode **7** in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. In this case, it is possible to more easily observe the support substrate **3** side, and it is possible to improve the resonance characteristics of the acoustic wave device **1**.
[0082] Here, the “width” of each of the through-hole **13***a* and the cutout portion **13***b*, provided in the first electrode layer **13**, and a portion between electrode fingers of the IDT electrode **7** is defined as the dimension thereof in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. It is preferable that the dimension, in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, of a portion where the first non-formation region D illustrated in FIG. **2** and a portion between electrode fingers overlap in plan view is about 0.8 times or greater and about 1 time or less of the width of the portion between electrode fingers. It is preferable that the width of each of the through-hole **13***a* and the cutout portion **13***b* provided in the first electrode layer **13** is about 0.8 times or greater and about 1 time or less of the width of a portion between electrode fingers. Thus, it is possible to easily observe the support substrate **3** side.
[0083] It is preferable that all of the first non-formation regions D of the piezoelectric substrate **2** are regions that overlap in plan view the through-holes **13***a* or the cutout portions **13***b* provided in the same first electrode layer **13**. In this case, it is sufficient that the acoustic wave device **1** includes only one first electrode layer **13** that overlaps the first formation region C of the piezoelectric substrate **2**. Thus, it is possible to more reliably stabilize the potential of the first electrode layer **13** that overlaps the IDT electrode **7** in plan view. Thus, it is possible to improve the resonance characteristics of the acoustic wave device **1**.
[0084] As illustrated in FIG. **3**, it is preferable that the piezoelectric substrate **2** includes a plurality of first non-formation regions D in the electrode finger extending direction. In the first example embodiment, a plurality of through-holes **13***a* and two cutout portions **13***b* are provided in the first electrode layer **13** so as to be arranged in the electrode finger extending direction. Thus, the plurality of first non-formation regions D are arranged as described above. Thus, it is possible to observe the support substrate **3** side in a wide range, and it is possible to increase the strength of the

first electrode layer **13**.

[0085] To be more specific, in the first example embodiment, a through-hole **13***a* and a cutout portion **13***b* are not provided in a portion of the first electrode layer **13** that overlaps each electrode finger in plan view. On the other hand, a plurality of through-holes **13***a* and two cutout portions **13***b* are provided in a portion of the first electrode layer **13** that overlaps in plan view a portion between electrode fingers. The first electrode layer **13** is provided between the plurality of through-holes **13***a* and between a through-hole **13***a* and a cutout portion **13***b*. Thus, the first electrode layer **13** has a structure such that portions that overlap electrode fingers in plan view are connected by a plurality of connection portions. Thus, it is possible to observe the support substrate **3** side in a wide range, and it is possible to increase the strength of the first electrode layer **13**.

[0086] Referring back to FIG. **2**, it is preferable that the piezoelectric substrate **2** includes a plurality of second non-formation regions Fa and a plurality of second non-formation regions Fb. Thus, it is possible to more easily observe the support substrate **3** side, and it is possible to more reliably identify an acoustic wave device **1** including a defect in the piezoelectric substrate **2**. However, the piezoelectric substrate **2** may include one second non-formation region Fa and may include one second non-formation region Fb.

[0087] It is preferable that at least some second non-formation regions Fa among all of the second non-formation regions Fa are arranged at a period that is an integer multiple of the reflector electrode finger pitch of the reflector **8**A in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. In the first example embodiment, the plurality of through-holes **14***a* provided in the second electrode layer **14**A are arranged at a period that is an integer multiple of the reflector electrode finger pitch of the reflector **8**A in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. The plurality of cutout portions **14***b* provided in the second electrode layer **14**A are also arranged at a period that is an integer multiple of the reflector electrode finger pitch of the reflector **8**A in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. Thus, the plurality of second non-formation regions Fa are disposed as described above. The term “reflector electrode finger pitch” refers to the center-to-center distance between adjacent reflector electrode fingers **8***a* in the acoustic wave propagation direction.

[0088] In the first example embodiment, the reflector **8**B is configured in the same or similar way to the reflector **8**A. The second electrode layer **14**B is configured in the same or similar way to the second electrode layer **14**A. The second non-formation regions Fb of the piezoelectric substrate **2** are configured in the same or similar way to the second non-formation regions Fa. Thus, at least some second non-formation regions Fb among all of the second non-formation regions Fb are arranged at a period that is an integer multiple of the reflector electrode finger pitch of the reflector **8**B in the direction orthogonal or substantially orthogonal to the electrode finger extending direction.

[0089] At least some portions of the reflector **8**A between the reflector electrode fingers **8***a* among all of the portions between the reflector electrode fingers **8***a* each overlap a corresponding one of the second non-formation regions Fa in plan view. The relationship between portions of the reflector **8**B between the reflector electrode fingers **8***a* and the second non-formation regions Fb is the same as or similar to the above. Thus, it is easy to observe the support substrate **3** side.

[0090] The periodic structure of the reflector **8**A and the reflector **8**B matches the periodic structure of the IDT electrode **7**. Thus, the second electrode layer **14**A and the second electrode layer **14**B have a periodic structure that matches the IDT electrode **7**, the reflector **8**A, and the reflector **8**B. Thus, it is possible to effectively improve the resonance characteristics of the acoustic wave device **1**. To be specific, for example, it is possible to effectively increase the Q-value.

[0091] It is preferable that all of the portions of the reflector **8**A between the reflector electrode fingers **8***a* each overlap a corresponding one of the second non-formation regions Fa in plan view. Similarly, it is preferable that all of the portions of the reflector **8**B between the reflector electrode fingers **8***a* each overlap a corresponding one of the second non-formation regions Fb in plan view. In these cases, it is possible to more easily observe the support substrate **3** side, and it is possible to effectively improve the resonance characteristics of the acoustic wave device **1**.

[0092] It is preferable that the first electrode layer **13** is not connected to the second electrode layer **14**A and the second electrode layer **14**B. In this case, a residue of a resist is not easily generated when the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are formed by a lift-off process, for example.

[0093] To be specific, to form the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B by a lift-off process, a resist pattern is provided on a surface on which the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are to be formed. The resist pattern has been patterned by removing a portion of a resist. To be more specific, the resist has been removed from portions of the resist pattern corresponding to the shapes of the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B. Next, an electrode layer is provided on the resist pattern. At this time, the electrode layer includes a portion provided on the resist and a portion provided on the portions from which the resist has been removed. Next, the resist pattern is peeled off. Through the above process, it is possible to form the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B.

[0094] In the first example embodiment, the first electrode layer **13** is not connected to the second electrode layer **14**A and the second electrode layer **14**B. Thus, the resist extends continuously in a portion of the resist pattern corresponding to a region between the first electrode layer **13** and the second electrode layer **14**A. Similarly, the resist extends continuously in a portion of the resist pattern corresponding to a region between the first electrode layer **13** and the second electrode layer **14**B. Thus, the resist pattern can be easily peeled off, and a resist residue is not easily generated.

[0095] As illustrated in FIG. **2**, it is preferable that the piezoelectric substrate **2** includes the dielectric layer **5**. The dielectric layer **5** is provided between the piezoelectric layer **6** and the first electrode layer **13**. Therefore, the IDT electrode **7** and the first electrode layer **13** face each other with the piezoelectric layer **6** and the dielectric layer **5** therebetween. Thus, electrostatic capacitance is provided. It is possible to easily adjust the magnitude of the electrostatic capacitance by adjusting the thickness of the dielectric layer **5**. Thus, it is possible to easily adjust the band width ratio.

[0096] It is preferable that the intermediate layer **4** includes a layer made of silicon oxide, for example. In the first example embodiment, the second layer **4**B is a layer made of silicon oxide, for example. Thus, it is possible to reduce the temperature coefficient of frequency (TCF) of the acoustic wave device **1**. Thus, it is possible to improve the frequency temperature characteristics of the acoustic wave device **1**.

[0097] In the first example embodiment, an example in which the shape of the first non-formation region D in plan view is a rectangle or substantially a rectangle has been described. However, the shape of the first non-formation region D in plan view is not limited to the above. The shape of the first non-formation region D in plan view may be, for example, a circle, an ellipse, a triangle, or a polygon other than a rectangle.

[0098] As illustrated in FIG. **1**, in the first example embodiment, the first electrode layer **13** does not overlap the first busbar **16** and the second busbar **17** of the IDT electrode **7** in plan view. However, the first electrode layer **13** may overlap the first busbar **16** or the second busbar **17** in plan view.

[0099] As illustrated in FIG. **2**, the cross-sectional shape of each electrode finger of the IDT electrode **7** is a trapezoid or substantially a trapezoid. To be specific, each electrode finger includes a first surface **7***a*, a second surface **7***b*, and a side surface **7***c*. The first surface **7***a* and the second surface **7***b* face each other in the thickness direction of the electrode finger. The side surface **7***c* is connected to the first surface **7***a* and the second surface **7***b*. The side surface **7***c* extends at an angle to the normal direction of the first main surface **6***a* of the piezoelectric layer **6**. However, the side surface **7***c* of each electrode finger may extend parallel or substantially parallel to the normal direction of the first main surface **6***a* of the piezoelectric layer **6**.

[0100] As illustrated in FIG. **1**, in the first example embodiment, the entirety or substantially the entirety of each through-hole **13***a* and each cutout portion **13***b* of the first electrode layer **13** overlaps in plan view a portion between electrode fingers of the IDT electrode **7**. Therefore, the entirety or substantially the entirety of each first non-formation region overlaps in plan view a portion between electrode fingers. Similarly, the entirety or substantially the entirety of each through-hole **14***a* and each cutout portion **14***b* of the second electrode layer **14**A and the second electrode layer **14**B also overlaps in plan view a portion between the reflector electrode fingers **8***a*. Therefore, the entirety or substantially the entirety of each second non-formation region overlaps in plan view a portion between the reflector electrode fingers **8***a*.

[0101] However, the disposition of each through-hole **13***a* and each cutout portion **13***b* of the first electrode layer **13** and each through-hole **14***a* and each cutout portion **14***b* of the second electrode layer **14**A and the second electrode layer **14**B is not limited to the above. For example, in a modification of the first example embodiment illustrated in FIG. **5**, a portion of each through-hole **13***c* and each cutout portion **13***d* of the first electrode layer **13**A overlaps the electrode finger of the IDT electrode **7** in plan view. Another portion of each through-hole **13***c* and each cutout portion **13***d* overlaps in plan view a portion between electrode fingers. To be specific, both end portions of each through-hole **13***c* and each cutout portion **13***d* in the direction parallel or substantially parallel to the acoustic wave propagation direction overlap electrode fingers in plan view. Therefore, a portion of each first non-formation region overlaps the electrode fingers in plan view.

[0102] Similarly, a portion of each through-hole **14***c* and each cutout portion **14***d* of a second electrode layer **14**C and a second electrode layer **14**D overlaps the reflector electrode finger **8***a* in plan view. Another portion of each through-hole **14***c* and each cutout portion **14***d* overlaps a portion between the reflector electrode fingers **8***a*. To be specific, both end portions of each through-hole **14***c* and each cutout portion **14***d* in the direction parallel or substantially parallel to the acoustic wave propagation direction overlap the reflector electrode fingers **8***a* in plan view. Therefore, a portion of each second non-formation region overlaps the reflector electrode fingers **8***a* in plan view.

[0103] Also with the present modification, as with the first example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **2** including a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device. In addition, as with the first example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device. The configuration of the first electrode layer **13**A may be a configuration such that a portion of at least one through-hole **13***c* or at least one cutout portion **13***d* overlaps an electrode finger of the IDT electrode **7**. Thus, the configuration of regions in the piezoelectric substrate **2** may be a configuration such that at least one first non-formation region overlaps an electrode finger in plan view. The configuration of the second electrode layer **14**C may be a configuration such that a portion of at least one through-hole **14***c* or at least one cutout portion **14***d* overlaps the reflector electrode finger **8***a*. Thus, the configuration of regions in the piezoelectric substrate **2** may be a configuration such that at least one second non-formation region overlaps the reflector electrode finger **8***a* in plan view. The same applies to the second electrode layer **14**D.

[0104] FIG. **6** is a schematic plan view of an acoustic wave device according to a second example embodiment of the present invention. FIG. **7** is a schematic plan view illustrating each region in the second example embodiment.

[0105] As illustrated in FIG. **6**, the present example embodiment differs from the first example embodiment in the configuration of a first electrode layer **23**, a second electrode layer **24**A, and a second electrode layer **24**B. Thus, the present example embodiment differs from the first example embodiment also in regions of the piezoelectric substrate **2**. In other respects, the acoustic wave device according to the present example embodiment has a configuration the same as or similar to that of the acoustic wave device **1** according to the first example embodiment.

[0106] The first electrode layer **23** does not include a through-hole. On the other hand, the first electrode layer **23** includes a plurality of cutout portions **23***b*. The plurality of cutout portions **23***b* are arranged in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. To be specific, in the present example embodiment, the plurality of cutout portions **23***b* are arranged at a period that is the same or substantially the same as the electrode finger pitch. Only one cutout portion **23***b* is provided in the electrode finger extending direction.

[0107] Thus, as illustrated in FIG. **7**, the piezoelectric substrate **2** includes only one first non-formation region D in the electrode finger extending direction. The piezoelectric substrate **2** includes a plurality of first non-formation regions D in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. To be more specific, the plurality of first non-formation regions D are arranged at a period that is the same or substantially the same as the electrode finger pitch in the direction orthogonal or substantially the same to the electrode finger extending direction.

[0108] The cutout portion **23***b* provided in the first electrode layer **23** has a slit shape, for example. To be more specific, the cutout portion **23***b* extends in the electrode finger extending direction. In the present example embodiment, the dimension of the cutout portion **23***b* in the electrode finger extending direction is, for example, about 0.5 times or greater and about 0.8 times or less of the dimension of the crossing region A in the electrode finger extending direction. Thus, the dimension of each first non-formation region D of the piezoelectric substrate **2** in the electrode finger extending direction is, for example, about 0.5 times or greater and about 0.8 times or less of the dimension of the crossing region A in the electrode finger extending direction. In this case, it is easy to observe the support substrate **3** side, and it is possible to make the strength of the first electrode layer **23** sufficiently high. However, the dimension of the cutout portion **23***b* and the first non-formation region D in the electrode finger extending direction may be less than, for example 0.5 times the dimension of the crossing region A in the electrode finger extending direction.

[0109] Similarly, the second electrode layer **24**A and the second electrode layer **24**B do not include a through-hole and each include a plurality of cutout portions **24***b*. Each cutout portion **24***b* has a slit shape, for example. The plurality of cutout portions **24***b* are arranged in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. To be specific, the plurality of cutout portions **24***b* are arranged at a period that is the same or substantially the same as the electrode finger pitch. Only one cutout portion **24***b* is provided in the electrode finger extending direction.

[0110] Thus, the piezoelectric substrate **2** includes only one second non-formation region Fa in the electrode finger extending direction. The piezoelectric substrate **2** includes a plurality of second non-formation regions Fa in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. To be more specific, the plurality of second non-formation regions Fa are arranged at a period that is the same or substantially the same as the reflector electrode finger pitch in the direction orthogonal or substantially orthogonal to the electrode finger extending direction. A plurality of second non-formation regions Fb are disposed in the same or similar way to the plurality of second non-formation regions Fa.

[0111] Also with the present example embodiment, as with the first example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **2** including a defect, and it is possible to reduce or present the occurrence of a fault in a product including an acoustic wave device. In addition, as with the first example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0112] In the present example embodiment, an example in which the shape of the cutout portion **23***b* is a slit shape has been described. The cutout portion **23***b* need not be provided in the first electrode layer **23**, and only one through-hole may be provided in the electrode finger extending direction. In this case, the through-hole may have a slit shape, for example.

[0113] FIG. **8** is a schematic bottom view illustrating the configuration of a first electrode layer and a second electrode layer in a third example embodiment of the present invention. FIG. **8** illustrates the electrode configuration of the dielectric layer **5** as seen from a direction corresponding to the downward direction in FIG. **2**. Therefore, FIG. **8** is left-right reversed compared with schematic plan views such as FIG. **1**. The same applies to schematic bottom views other than FIG. **8**.

[0114] The present example embodiment differs from the first example embodiment in that the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are connected. In other respects, an acoustic wave device according to the present example embodiment has a configuration the same as or similar to that of the acoustic wave device **1** according to the first example embodiment.

[0115] The first electrode layer **13** and the second electrode layer **14**A are connected by a connection electrode **35**. Similarly, the first electrode layer **13** and the second electrode layer **14**B are connected by another connection electrode **35**. The first electrode layer **13**, each connection electrode **35**, and each second electrode layer are integrally provided. In FIG. **8**, the boundaries between the first electrode layer **13**, each second electrode layer, and each connection electrode **35** are shown by two-dot chain lines. However, for example, the first electrode layer **13**, each second electrode layer, and each connection electrode **35** may be independently provided from different materials, and the first electrode layer **13** and each second electrode layer may be connected by each connection electrode **35**.

[0116] Also with the present example embodiment, as with the first example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **2** including a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device. In addition, as with the first example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0117] FIG. **9** is a schematic bottom view illustrating the configuration of a first electrode layer and a second electrode layer in a fourth example embodiment of the present invention.

[0118] The present example embodiment differs from the first example embodiment in that a plurality of first electrode layers **43**, a plurality of second electrode layers **44**A, and a plurality of second electrode layers **44**B are provided. In other respects, an acoustic wave device according to the present example embodiment has a configuration the same as or similar to that of the acoustic wave device **1** according to the first example embodiment.

[0119] The plurality of first electrode layers **43** extend in the electrode finger extending direction, as with a plurality of electrode fingers of the IDT electrode **7**. The plurality of first electrode layers **43** are arranged in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, as with the plurality of electrode fingers.

[0120] The plurality of first electrode layers **43** overlap the plurality of electrode fingers of the IDT electrode **7** in plan view. On the other hand, the plurality of first electrode layers **43** do not overlap the portions between electrode fingers in plan view. Thus, in the piezoelectric substrate **2**, a plurality of first non-formation regions are provided. That is, in the present example embodiment, each first non-formation region is a region of the piezoelectric substrate **2** that overlaps in plan view a portion between the first electrode layers **43** that are adjacent to each other. The plurality of first non-formation regions each overlap in plan view a portion between electrode fingers.

[0121] The plurality of second electrode layers **44**A overlap the plurality of reflector electrode fingers **8***a* of the reflector **8**A in plan view. On the other hand, the plurality of second electrode layers **44**A do not overlap in plan view the portions between the reflector electrode fingers **8***a* of the reflector **8**Aw. Thus, in the piezoelectric substrate **2**, a plurality of second non-formation regions are provided. These second non-formation regions are regions of the piezoelectric substrate **2** that overlap in plan view the portions between adjacent second electrode layers **44**A. The plurality of second non-formation regions each overlap in plan view a corresponding one of the portions between the reflector electrode fingers **8***a* of the reflector **8**A.

[0122] Similarly, the plurality of second electrode layers **44**B overlap the plurality of reflector electrode fingers **8***a* of the reflector **8**B in plan view. On the other hand, the plurality of second electrode layers **44**B do not overlap in plan view the portions between the reflector electrode fingers **8***a* of the reflector **8**B. Thus, in the piezoelectric substrate **2**, a plurality of second non-formation regions are provided. These second non-formation regions are regions of the piezoelectric substrate **2** that overlap in plan view the portions between adjacent second electrode layers **44**B. The plurality of second non-formation regions each overlap a corresponding one of the portions between the reflector electrode fingers **8***a* of the reflector **8**B in plan view.

[0123] Also with the present example embodiment, as with the first example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **2** including a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device. In addition, as with the first example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0124] FIG. **10** is a schematic front sectional view of an acoustic wave device according to a fifth example embodiment of the present invention.

[0125] The present example embodiment differs from the first example embodiment in the configuration of a piezoelectric substrate **52**. In other respects, the acoustic wave device according to the present example embodiment has a configuration the same as or similar to that of the acoustic wave device **1** according to the first example embodiment.

[0126] The piezoelectric substrate **52** includes the support substrate **3**, an intermediate layer **54**, the dielectric layer **5**, and the piezoelectric layer **6**. A hollow portion **52***a* is provided in the piezoelectric substrate **52**. To be specific, the intermediate layer **54** includes a recessed portion **54***a*. The dielectric layer **5** is provided on the intermediate layer **54** so as to cover the recessed portion **54***a*. Thus, the hollow portion **52***a* is provided. In the hollow portion **52***a*, the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are provided.

[0127] The intermediate layer **54** includes a side wall portion, facing the recessed portion **54***a*, and a bottom portion. The side wall portion of the intermediate layer **54** is joined to the dielectric layer **5**. The bottom portion of the intermediate layer **54** is joined to the support substrate **3**. The bottom portion of the intermediate layer **54** is positioned between the first electrode layer **13**, the second electrode layer **14**A, the second electrode layer **14**B, and the support substrate **3**.

[0128] It is possible to increase the closeness of contact between the support substrate **3** and the piezoelectric layer **6**, because the intermediate layer **54** and the dielectric layer **5** are provided between the support substrate **3** and the piezoelectric layer **6**. Moreover, it is possible to effectively confine the energy of an acoustic wave in the piezoelectric layer **6** side, because the hollow portion **52***a* is provided in the piezoelectric substrate **52**. For example, a recessed portion may be provided in the support substrate **3**, and the piezoelectric layer **6** may be provided directly on the support substrate **3** so as to cover the recessed portion of the support substrate **3**.

[0129] Also with the present example embodiment, as with the first example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **52** including a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device. In addition, as with the first example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0130] It is possible to use acoustic wave devices according to example embodiments of the present invention in, for example, a filter device. This example will be described below.

[0131] FIG. **11** is a circuit diagram of a filter device according to a sixth example embodiment of the present invention.

[0132] A filter device **60** is a ladder filter, for example. The filter device **60** includes a first signal terminal **62**, a second signal terminal **63**, a plurality of serial-arm resonators, and a plurality of parallel-arm resonators. In the present example embodiment, all of the serial-arm resonators and all of the parallel-arm resonators are acoustic wave resonators. One of the serial-arm resonators and one of the parallel-arm resonators are acoustic wave devices according to example embodiments of the present invention. The other serial-arm resonators and the other parallel-arm resonators are not acoustic wave devices according to example embodiments of the present invention. To be more specific, the other serial-arm resonators and the other parallel-arm resonators do not include a first electrode layer and a second electrode layer according to an example embodiment of the present invention.

[0133] However, it is sufficient that at least one of the serial-arm resonators or at least one of the parallel-arm resonators of the filter device **60** is an acoustic wave device according to an example embodiment the present invention. For example, all of the serial-arm resonators and all of the parallel-arm resonators may be acoustic wave devices according to example embodiments of the present invention.

[0134] As illustrated in FIG. **11**, the first signal terminal **62** and the second signal terminal **63** may be, for example, electrode pads, or may be wiring lines. In the present example embodiment, the first signal terminal **62** is an antenna terminal, for example. The antenna terminal is to be connected to an antenna.

[0135] The plurality of serial-arm resonators of the filter device **60** include a serial-arm resonator S**1**, a serial-arm resonator S**2**, and a serial-arm resonator S**3**. The plurality of parallel-arm resonator include a parallel-arm resonator P**1** and a parallel-arm resonator P**2**.

[0136] The serial-arm resonator S**1**, the serial-arm resonator S**2**, and the serial-arm resonator S**3** are serially connected to each other between the first signal terminal **62** and the second signal terminal **63**. The parallel-arm resonator P**1** is connected between the ground potential and a connection point between the serial-arm resonator S**1** and the serial-arm resonator S**2**. The parallel-arm resonator P**2** is connected between the ground potential and a connection point between the serial-arm resonator S**2** and the serial-arm resonator S**3**. In the present example embodiment, the serial-arm resonator S**1** and the parallel-arm resonator P**1** are acoustic wave devices according to example embodiments of the present invention. However, the arrangement of a serial-arm resonator or a parallel-arm resonator that is an acoustic wave device according to an example embodiment of the present invention is not particularly limited.

[0137] The circuit configuration of the filter device **60** is not limited to the above. It is sufficient that the filter device **60** includes at least one serial-arm resonator and at least one parallel-arm resonator. Alternatively, a filter device according to the present invention is not limited to a ladder filter. For example, a filter device may include a longitudinally coupled resonator acoustic wave filter and at least one acoustic wave resonator. In this case, it is sufficient that the at least one acoustic wave resonator is an acoustic wave device according to an example embodiment of the present invention.

[0138] The filter device **60** includes an acoustic wave device according to an example embodiment of the present invention. In a process of obtaining the acoustic wave device, it is possible to identify an acoustic wave device if the acoustic wave device includes a defective substrate. Therefore, as an acoustic wave resonator of the filter device **60**, it is possible to more reliably use an acoustic wave device that does not include a defect. Thus, it is possible to reduce or prevent the occurrence of a fault in the filter device **60**.

[0139] As in the present example embodiment, it is preferable that the filter device **60** includes an acoustic wave resonator including a first electrode layer and a second electrode layer according to an example embodiment of the present invention and an acoustic wave resonator not including a first electrode layer and a second electrode layer according to an example embodiment of the present invention. Thus, it is possible to appropriately widen the pass band, and it is possible to improve attenuation characteristics near a frequency at an end portion on the higher side of the pass band or a frequency on the lower side of the pass band. This will be described below.

[0140] FIG. **12** illustrates the impedance frequency characteristics of an acoustic wave resonator including a first electrode layer and a second electrode layer and an acoustic wave resonator not including a first electrode layer and a second electrode layer in the sixth example embodiment. In FIG. **12**, the resonant frequencies of both of the acoustic wave resonators are adjusted to be the same or substantially the same.
[0141] As illustrated in FIG. **12**, the difference between the resonant frequency and the anti-resonant frequency of the acoustic wave resonator including a first electrode layer and a second electrode layer is small. Here, the band width ratio of an acoustic wave resonator is represented as $(|fr-fa|/fr)\times 100$ [%], where fr is the resonant frequency and fa is the anti-resonant frequency. The value of the band width ratio of the acoustic wave resonator including a first electrode layer and a second electrode layer is small. On the other hand, the value of the band width ratio of the acoustic wave resonator not including a first electrode layer and a second electrode layer is large. In this way, it can be seen that an acoustic wave device according to an example embodiment of the present invention has a relatively small band width ratio.
[0142] Thus, by using an acoustic wave device according to an example embodiment of the present invention as a parallel-arm resonator in a filter device, it is possible to improve attenuation characteristics on the lower side of the pass band. To be more specific, it is possible to increase steepness on the lower side of the pass band. In the present specification, “steepness is high” means that a change in frequency relative to a change in attenuation is small near an end portion of the pass band.
[0143] Moreover, it is possible to attenuation characteristics on the higher side of the pass band by using an acoustic wave device according to an example embodiment of the present invention as a serial-arm resonator in a filter device. To be more specific, it is possible to increase steepness on the higher side of the pass band.
[0144] On the other hand, the band width ratio of the acoustic wave resonator not including a first electrode layer and a second electrode layer is relatively large. Thus, it is possible to easily widen the pass band by using the acoustic wave resonator in a filter device.
[0145] Hereafter, the direction orthogonal or substantially orthogonal to the electrode finger extending direction will be referred to as “electrode finger orthogonal direction”. In the first example embodiment described above, as illustrated in FIG. **3**, some first non-formation regions D among all of the first non-formation regions D are arranged in the electrode finger extending direction. Some first non-formation regions D among all of the first non-formation regions D are arranged in the electrode finger orthogonal direction. Here, a first imaginary line is defined as an imaginary line that extends in the electrode finger orthogonal direction and passes through a midpoint between the first non-formation regions D that are adjacent to each other in the electrode finger extending direction. In the example schematically illustrated in FIG. **3**, four first imaginary lines can be drawn. The first non-formation regions D are not positioned on any of the first imaginary lines.
[0146] In the above example, the first imaginary line is defined by using the first non-formation regions D. It is possible to define the first imaginary line in the same or similar way by using the through-holes **13***a* and the cutout portions **13***b* of the first electrode layer **13** illustrated in FIG. **1** when seen in plan view. Thus, the first imaginary line will be used in the same or similar way in describing the disposition of the first non-formation regions D, the through-holes **13***a*, and the cutout portions **13***b*. FIG. **13** is a schematic plan view of an acoustic wave device according to a seventh example embodiment of the present invention. FIG. **14** is a schematic plan view illustrating each region near a portion overlapping a first electrode layer in plan view and first imaginary lines in the seventh example embodiment. In FIG. **13**, only one first imaginary line G**1** among a plurality of first imaginary lines G**1** is drawn.
[0147] As illustrated in FIG. **13**, the present example embodiment differs from the fifth example embodiment illustrated in FIG. **10** in the configuration of a first electrode layer **73**. Thus, as

illustrated in FIG. **14**, the present example embodiment differs from the fifth example embodiment also in the arrangement of regions in the piezoelectric substrate **2**. This is synonymous with the fact that the present example embodiment differs from the first example embodiment illustrated in FIG. **3** in the arrangement of regions in the piezoelectric substrate **2**. In other respects, the acoustic wave device according to the present example embodiment has a configuration the same as or similar to that of the acoustic wave device according to the fifth example embodiment.

[0148] As illustrated in FIG. **13**, some through-holes **13***a* among all of the through-holes **13***a* of the first electrode layer **73** are arranged in the electrode finger extending direction. Some through-holes **13***a* among all of the through-holes **13***a* are arranged in the electrode finger orthogonal direction. The plurality of cutout portions **13***b* are arranged in the electrode finger orthogonal direction. In the present example embodiment, the through-holes **13***a* are disposed in a staggered manner. To be specific, the through-holes **13***a* that are arranged in the electrode finger orthogonal direction are positioned on the first imaginary line G**1**.

[0149] Thus, as illustrated in FIG. **14**, in the piezoelectric substrate **2**, some first non-formation regions D among all of the first non-formation regions D are arranged in the electrode finger extending direction. Some first non-formation regions D among all of the first non-formation regions D are arranged in the electrode finger orthogonal direction. The first non-formation regions D are disposed in a staggered manner. To be specific, the first non-formation regions D that are arranged in the electrode finger orthogonal direction are positioned on the first imaginary lines G**1**.

[0150] Also with the present example embodiment, as with the fifth example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **2** including a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device. In addition, as with the fifth example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0151] FIG. **15** is a schematic plan view illustrating each region near a portion overlapping the first electrode layer in plan view, second imaginary lines, and a third imaginary line in the seventh example embodiment.

[0152] A second imaginary line G**2** is an imaginary line that extends in the electrode finger orthogonal direction, that passes through a midpoint between two first non-formation regions D that are adjacent to each other in the electrode finger extending direction, and that extends from one end to the other end of the crossing region A in the electrode finger orthogonal direction. The second imaginary line G**2** is a portion of the first imaginary line G**1** drawn in FIG. **14**. It is also possible to define the second imaginary line G**2** in the same or similar way by using the through-holes **13***a* and the cutout portions **13***b* of the first electrode layer **73** when seen in plan view. Thus, the second imaginary line G**2** will be used in the same or similar way in describing the disposition of the first non-formation regions D, the through-holes **13***a*, and the cutout portions **13***b*.

[0153] Hereafter, a first length L**1** is defined as the total length of portions where the first non-formation regions D are positioned on one second imaginary line G**2**, and a second length L**2** is defined as the total length of portions where the first non-formation regions D are not positioned on one second imaginary line G**2**. When Rmax is defined as the maximum value and Rmin is defined as the minimum value of the ratio L**1**/L**2** between the first length L**1** and the second length L**2** for all of the second imaginary lines G**2**, in the present example embodiment, (Rmax-Rmin)/Rmin is 0. Thus, it is possible to make the acoustic wave propagation velocity in the crossing region A uniform or substantially uniform.

[0154] To be more specific, the first length L**1** is the same or substantially the same as the total length of portions where the through-holes **13***a* and the cutout portions **13***b* illustrated in FIG. **13** are positioned on one second imaginary line G**2**. A mass is not applied to the piezoelectric substrate **2** by portions where the through-holes **13***a* and the cutout portions **13***b* are positioned in the first electrode layer **73**. On the other hand, the second length L**2** is the same or substantially the same as the total length of portions where the through-hole **13***a* and the cutout portion **13***b* are not positioned on one second imaginary line G**2**. A mass is applied to the piezoelectric substrate **2** by portions where the through-hole **13***a* and the cutout portion **13***b* are not positioned in the first electrode layer **73**.

[0155] Therefore, the ratio L**1**/L**2** is the ratio between the length of a portion where a mass is not applied to the piezoelectric substrate **2** by the first electrode layer **73** and the length of a portion where a mass is applied to the piezoelectric substrate **2** by the first electrode layer **73**. Here, "length" refers a dimension in the electrode finger orthogonal direction. The acoustic wave propagation velocity in the crossing region A of the piezoelectric substrate **2** depends on the degree of application of a mass. Thus, the more uniform the ratio L**1**/L**2** in the crossing region A, the more uniform the acoustic wave propagation velocity in the crossing region A.

[0156] When (Rmax-Rmin)/Rmin is 0, the ratio L**1**/L**2** is uniform in all portions on the second imaginary line G**2**. Thus, it is possible to make the acoustic wave propagation velocity in the crossing region A uniform or substantially uniform. Thus, it is possible to reduce or prevent transverse modes, which are unnecessary waves.

[0157] It is not necessary that (Rmax−Rmin)/Rmin is 0. It is preferable that (Rmax−Rmin)/Rmin is, for example, about 1.25 or less. Also in this case, the ratio L**1**/L**2** is approximately uniform in the crossing region A. Thus, it is possible to reduce or prevent transverse modes. However, it is more preferable that (Rmax−Rmin)/Rmin is 0.

[0158] A third imaginary line G**3** drawn in FIG. **15** is an imaginary line that extends in the electrode finger orthogonal direction and that extends from one end to the other end of the crossing region A in the electrode finger orthogonal direction. Although it is possible to draw an infinite number of third imaginary lines G**3**, FIG. **15** illustrates an example of the third imaginary line G**3**. Imaginary lines that coincide with the second imaginary lines G**2** are also included in a plurality of third imaginary lines G**3**.

[0159] Hereafter, a third length L**3** is defined as the total length of portions where the first non-formation regions D are positioned on one third imaginary line G**3**, and a fourth length L**4** is defined as the total length of portions where the first non-formation regions D are not positioned on one third imaginary line G**3**. A uniform portion H, for example, is defined as a portion where a third imaginary line such that the ratio L**3**/L**4** between the third length L**3** and the fourth length L**4** is about 1 time or less of the maximum value Rmax and about 1 time or greater of the minimum value Rmin is positioned. In the present example embodiment, the crossing region A includes at least one uniform portion H. To be specific, in the present example embodiment, the crossing region A includes one uniform portion H. To be more specific, the uniform portion H is positioned in the entirety or substantially the entirety of the crossing region A.

[0160] In the uniform portion H, the ratio L**3**/L**4** is approximately uniform. Thus, in the uniform portion H, acoustic wave propagation velocity is approximately uniform. In the present example embodiment, the uniform portion H is positioned in the entirety or substantially the entirety of the crossing region A. Accordingly, in the entirety or substantially the entirety of the crossing region A, acoustic wave propagation velocity is approximately uniform. Thus, it is possible to further reduce or prevent transverse modes.

[0161] However, the uniform portion H need not be positioned in the entirety or substantially the entirety of the crossing region A. The crossing region A may include a plurality of uniform portions H. This example will be described as a first modification and a second modification of the seventh example embodiment.

[0162] FIG. **16** is a schematic plan view illustrating each region near a portion overlapping a first electrode layer in plan view, a third imaginary line, and some uniform portions in the first modification of the seventh example embodiment. In FIG. **16**, three uniform portions H that are arranged from a lower portion of FIG. **16** are illustrated, and the other uniform portions H are omitted.

[0163] In the first modification, a plurality of uniform portions H are arranged in the electrode finger extending direction. To be more specific, in a portion of the crossing region A, the length L**3** in the third imaginary line G**3** is about 0. In this portion, the ratio L**3**/L**4** is about 0, and is less than about 1 time Rmin. Therefore, this portion is not a uniform portion H. Uniform portions H and portions that are not uniform portions H are alternately arranged in the electrode finger extending direction.

[0164] In the first modification, for example, the total area of all of the uniform portions is about 80% or greater of the area of the crossing region A. Thus, it is possible to effectively make acoustic wave propagation velocity in the crossing region A uniform or substantially uniform. Thus, it is possible to effectively reduce or prevent transverse modes.

[0165] FIG. **17** is a schematic plan view illustrating each region near a portion overlapping a first electrode layer in plan view, a third imaginary line, and some uniform portions in a second modification of the seventh example embodiment of the present invention. In FIG. **17**, three uniform portions H that are arranged from a lower portion of FIG. **17** are illustrated, and the other uniform portions H are omitted.

[0166] In the second modification, for example, in a portion of the crossing region A, the ratio L**3**/L**4** based on regions on the third imaginary line G**3** is greater than about 1 time Rmax. Therefore, this portion is not a uniform portion H. Uniform portions H and portions that are not uniform portions H are arranged alternately in the electrode finger extending direction.

[0167] In the second modification, for example, the total area of all of the uniform portions H is about 80% or greater of the area of the crossing region A. Thus, it is possible to effectively make acoustic wave propagation velocity in the crossing region A uniform. Thus, it is possible to effectively reduce or prevent transverse modes.

[0168] With the first modification and the second modification, as with the seventh example embodiment, it is possible to identify an acoustic wave device including a piezoelectric substrate **2** including a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device. Moreover, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0169] In the seventh example embodiment, the first modification, and the second modification, the plurality of first non-formation regions D are arranged at a period that is an integer multiple of the electrode finger pitch in the electrode finger orthogonal direction. Thus, it is possible to more easily observe the support substrate **3** side, and it is possible to improve the resonance characteristics of an acoustic wave device.

[0170] As described above, it is possible to use an acoustic wave device according to an example embodiment of the present invention in a filter device or the like. For example, an acoustic wave device according to an example embodiment of the present invention may include a wiring line provided on a piezoelectric layer. An acoustic wave device according to an example embodiment the present invention may include an electrode layer other than a first electrode layer and a second electrode layer. This example will be described in an eighth example embodiment of the present invention.

[0171] FIG. **18** is a schematic plan view of an acoustic wave device according to the eighth example embodiment. FIG. **19** is a schematic sectional view taken along line II-II in FIG. **18**. In FIG. **18**, the boundaries between wiring lines and the first and second busbars **16** and **17** are shown by two-dot chain lines.

[0172] As illustrated in FIG. **18**, the present example embodiment differs from the first example embodiment in that an acoustic wave device **81** includes a plurality of wiring lines and a plurality of third electrode layers. To be specific, the plurality of third electrode layers in the present example embodiment include a third electrode layer **85**A and a third electrode layer **85**B. As illustrated in FIG. **19**, the present example embodiment differs from the first example embodiment also in the stacking configuration of a piezoelectric substrate **82**. In other respects, the acoustic wave device **81** according to the present example embodiment has a configuration the same as or similar to that of the acoustic wave device **1** according to the first example embodiment.

[0173] The piezoelectric substrate **82** includes the support substrate **3**, an intermediate layer **84**, and the piezoelectric layer **6**. In the present example embodiment, the intermediate layer **84** is a single-layer dielectric film. To be specific, for example, silicon oxide is used as the material of the intermediate layer **84**. However, the material of the intermediate layer **84** is not limited to the above. The support substrate **3**, the intermediate layer **84**, and the piezoelectric layer **6** are stacked in this order.

[0174] As illustrated in FIG. **18**, the plurality of wiring lines of the acoustic wave device **81** are provided on the first main surface **6***a* of the piezoelectric layer **6**. To be specific, the plurality of wiring lines include a first wiring line **83**A, a second wiring line **83**B, and a third wiring line **83**C. The first wiring line **83**A and the third wiring line **83**C are connected to the IDT electrode **7**. To be more specific, the first wiring line **83**A is connected to the second busbar **17** of the IDT electrode **7**. The third wiring line **83**C is connected to the first busbar **16** of the IDT electrode **7**. Thus, the first wiring line **83**A and the third wiring line **83**C are connected to different potentials.

[0175] On the other hand, the second wiring line **83**B is not connected to the IDT electrode **7**. The second wiring line **83**B is connected to a potential different from the potential to which the first wiring line **83**A is connected. The second wiring line **83**B may be connected to, for example, an element other than the acoustic wave device **81**. Alternatively, if the first wiring line **83**A is not connected to the ground potential, the second wiring line **83**B may be connected to the ground potential.

[0176] The third electrode layer **85**A and the third electrode layer **85**B are provided between the support substrate **3** and the piezoelectric layer **6**. To be more specific, as illustrated in FIG. **19**, the third electrode layer **85**A and the third electrode layer **85**B are provided directly on the second main surface **6***b* of the piezoelectric layer **6**. The third electrode layer **85**A and the third electrode layer **85**B are not in contact with each other. Although not illustrated, a first electrode layer and each second electrode layer are directly provided on the second main surface **6***b* of the piezoelectric layer **6**.

[0177] The third electrode layer **85**A overlaps the first wiring line **83**A in plan view. The third electrode layer **85**B overlaps the second wiring line **83**B in plan view. Thus, the third electrode layer **85**A and the third electrode layer **85**B define and function as electromagnetic shields for the first wiring line **83**A and the second wiring line **83**B. Thus, it is possible to reduce or prevent an electrical influence from the support substrate **3** side or from the outside.

[0178] In the present example embodiment, the third electrode layer **85**A and the third electrode layer **85**B are not in contact with each other. Thus, it is possible to reduce or prevent a mutual electrical influence between the first wiring line **83**A and the second wiring line **83**B that are connected to different potentials. One third electrode layer may overlap the first wiring line **83**A and the second wiring line **83**B in plan view. Also in this case, the third electrode layer defines and functions as an electromagnetic shield for the first wiring line **83**A and the second wiring line **83**B.

[0179] Referring back to FIG. **18**, the third electrode layer **85**A and the third electrode layer **85**B do not overlap the IDT electrode **7**, the reflector **8**A, and the reflector **8**B in plan view. Thus, it is possible to increase the heat dissipation of a portion where the IDT electrode **7** and each reflector are not provided.

[0180] In the acoustic wave device **81**, the first electrode layer **13** overlaps the IDT electrode **7** in plan view. The second electrode layer **14**A overlaps the reflector **8**A in plan view. The second electrode layer **14**B overlaps the reflector **8**B in plan view. Thus, it is also possible to increase the heat dissipation of portions where the IDT electrode **7** and each reflector are provided. In these ways, with the present example embodiment, it is possible to increase the heat dissipation of the acoustic wave device **81**.

[0181] In the present example embodiment, the first electrode layer **13**, the second electrode layer **14**A, and the second electrode layer **14**B are configured the same as or similar to those in the first example embodiment. Thus, it is possible to identify an acoustic wave device **81** including a piezoelectric substrate **82** having a defect, and it is possible to reduce or prevent the occurrence of a fault in a product including an acoustic wave device **81**. In addition, as with the first example embodiment, it is also possible to increase the electrostatic capacitance of an acoustic wave device.

[0182] The arrangement of the plurality of third electrode layers in the acoustic wave device **81** is not limited to the above. It is sufficient that a plurality of third electrode layers do not overlap the crossing region in plan view. For example, the plurality of third electrode layers need not overlap any of a plurality of wiring lines in plan view. Also in this case, because the plurality of third electrode layers are provided, it is possible to increase the heat dissipation of a portion other than the crossing region.

[0183] It is preferable that the third electrode layer does not overlap each reflector in plan view. In this case, it is possible to arrange each second electrode layer so as to overlap each reflector in plan view. Thus, it is possible to more reliably identify an acoustic wave device **81** including a piezoelectric substrate **82** including a defect.

[0184] It is preferable that the main component of the material of each third electrode layer is the same as the main component of the material of the first electrode layer **13**. Similarly, it is preferable that the main component of the material of each second electrode layer be the same as the main component of the material of the first electrode layer **13**. Thus, unevenness in the application of a mass to the piezoelectric substrate **82** does not easily occur, and stress concentration does not easily occur. In the present specification, “main component” refers to a component included by about 50% or more.

[0185] The acoustic wave device **81** includes two third electrode layers **85**A and the third electrode layer **85**B as the plurality of third electrode layers. However, it is sufficient that the acoustic wave device **81** include at least one third electrode layer.

[0186] Hereafter, an example of a filter device in which a plurality of acoustic wave device each including a plurality of third electrode layers are used will be described. Hereafter, a first busbar and a second busbar may be simply referred to as “busbar”.

[0187] FIG. **20** is a schematic plan view of a filter device according to a ninth example embodiment of the present invention. In FIG. **20**, each reflector and each second electrode layer are omitted. In FIG. **20**, through-holes and cutout portions in each first electrode layer **13** are also omitted. In FIG. **20**, the boundary between each busbar and a wiring line is shown by a two-dot chain line. In FIG. **20**, electrodes that are provided on the first main surface **6***a* of the piezoelectric layer **6** and connected to different potentials are shown by different hatching patterns.

[0188] A filter device **90** is a ladder filter, for example. To be specific, the filter device **90** includes serial-arm resonators and two parallel-arm resonators. In the present example embodiment, all of the serial-arm resonators and all of the parallel-arm resonators are acoustic wave devices according to example embodiments of the present invention. Each acoustic wave device **91** in the present example embodiment shares the same piezoelectric substrate **2**. The stacking configuration of the piezoelectric substrate **2** is the same as or similar to that in the first example embodiment.

[0189] The first electrode layer **13** of each acoustic wave device **91** is configured the same as or similar to that in the first example embodiment. Therefore, it is possible to identify an acoustic wave device **91** if the acoustic wave device **91** includes a defective substrate in a process of obtaining these acoustic wave devices **91**. Thus, it is possible to more reliably use, as an acoustic wave resonator of the filter device **90**, each acoustic wave device **91** that does not include a defect. Accordingly, it is possible to reduce or prevent the occurrence of a fault in the filter device **90**.

[0190] Each acoustic wave device **91** of the filter device **90** includes at least one wiring line **93**. That is, the filter device **90** includes a plurality of wiring lines **93**. The acoustic wave devices **91** are connected to each other by some wiring lines **93** among all of the wiring lines **93**. The filter device **90** includes a plurality of electrode pads **96**. The plurality of electrode pads **96** and the plurality of acoustic wave devices **91** are connected by some wiring lines **93** among all of the wiring lines **93**.

The filter device **90** is connected to a signal potential or a ground potential via the plurality of electrode pads **96**.

[0191] In the present example embodiment, the electrode pad **96** or the busbar of the acoustic wave device **91** and the wiring line **93** are integrally provided. However, the electrode pad **96** and the wiring line **93** may be independently made of different materials, and may be connected to each other. The busbar and the wiring line **93** may be independently made of different materials, and may be connected to each other.

[0192] The filter device **90** includes, as a plurality of third electrode layers, a plurality of third electrode layers **95**A, a plurality of third electrode layers **95**B, and a plurality of third electrode layers **95**C. Each acoustic wave device **91** includes at least one third electrode layer among the third electrode layer **95**A, the third electrode layer **95**B, and the third electrode layer **95**C.

[0193] The plurality of third electrode layers **95**A, the plurality of third electrode layers **95**B, and the plurality of third electrode layers **95**C are each provided between the support substrate **3** and the piezoelectric layer **6**. To be more specific, as with the first electrode layer **13** in the first example embodiment illustrated in FIG. **2**, the plurality of third electrode layers **95**A, the plurality of third electrode layers **95**B, and the plurality of third electrode layers **95**C are provided on the intermediate layer **4** side of the dielectric layer **5**. The plurality of third electrode layers **95**A, the plurality of third electrode layers **95**B, and the plurality of third electrode layers **95**C are not in contact with each other.

[0194] As illustrated in FIG. **20**, the third electrode layer **95**A overlaps the wiring line **93** and the busbar in plan view. The third electrode layer **95**B overlaps the electrode pad **96** in plan view. The third electrode layer **95**C does not overlap any of the wiring line **93** and the electrode pad **96** in plan view.

[0195] Because the plurality of third electrode layers **95**A, the plurality of third electrode layers **95**B, and the plurality of third electrode layers **95**C are provided, as with the eighth example embodiment, it is possible to reduce or prevent an electrical influence from the support substrate **3** side or from the outside. In addition, because the plurality of third electrode layers **95**A, the plurality of third electrode layers **95**B, and the plurality of third electrode layers **95**C are not in contact with each other, it is possible to reduce or prevent a mutual electrical influence between the wiring lines **93** and the electrode pads **96** having different potentials.

[0196] The third electrode layer **95**C is positioned between two third electrode layers **95**B. These third electrode layers **95**B respectively overlap in plan view the electrode pads **96** that are connected to different potentials. In this case, the third electrode layer **95**C defines and functions as an electromagnetic shield between the two third electrode layers **95**B. This configuration is particularly preferable when the two third electrode layer **95**B respectively overlap in plan view the electrode pads **96** that are connected to different signal potentials. To be specific, it is possible to effectively reduce or prevent a mutual electrical influence between the electrode pads **96**.

[0197] Alternatively, the third electrode layer **95**C may be positioned between the third electrode layer **95**A and the third electrode layer **95**B that respectively overlap in plan view the wiring line **93** and the electrode pad **96** that are connected to different signal potentials. In this case, it is possible to effectively reduce or prevent a mutual electrical influence between the wiring line **93** and the electrode pad **96**.

[0198] The third electrode layer **95**C may be positioned between the third electrode layers **95**A that respectively overlap in plan view the wiring lines **93** that are connected to different signal potential. In this case, it is possible to reduce or prevent a mutual electrical influence between the wiring lines **93**.

[0199] While example 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.

Claims

1. An acoustic wave device comprising: a piezoelectric substrate including a piezoelectric layer including a first main surface and a second main surface facing each other and a support substrate stacked on a second main surface side of the piezoelectric layer; at least one first electrode layer between the support substrate and the piezoelectric layer and not connected to a signal potential; and an IDT electrode on the first main surface of the piezoelectric layer and including a plurality of electrode fingers; wherein when an electrode finger extending direction is defined as a direction in which the plurality of electrode fingers extend and the IDT electrode is seen from a direction orthogonal or substantially orthogonal to the electrode finger extending direction, a region where electrode fingers of the plurality of electrode fingers adjacent to each other overlap is a crossing region; the first electrode layer is provided at least at a position overlapping the crossing region in plan view; the piezoelectric substrate includes a first formation region overlapping the crossing region and overlapping the first electrode layer in plan view and a first non-formation region overlapping the crossing region and not overlapping the first electrode layer in plan view; and the first non-formation region overlaps in plan view at least one of portions between the electrode fingers adjacent to each other.

2. The acoustic wave device according to claim 1, wherein at least one through-hole is provided in the first electrode layer; and the first non-formation region includes a region of the piezoelectric substrate overlapping the through-hole in plan view.

3. The acoustic wave device according to claim 1, wherein at least one cutout portion is provided in the first electrode layer; and the first non-formation region includes a region of the piezoelectric substrate overlapping the cutout portion in plan view.

4. The acoustic wave device according to claim 1, wherein the at least one first electrode layer includes only one first electrode layer.

5. The acoustic wave device according to claim 1, further comprising: a plurality of the first electrode layers; wherein the first non-formation region includes a region of the piezoelectric substrate overlapping in plan view a portion between the first electrode layers that are adjacent to each other.

6. The acoustic wave device according to claim 1, wherein the piezoelectric substrate includes a plurality of the first non-formation regions; and at least some of the plurality of first non-formation regions are arranged at a period that is an integer multiple of an electrode finger pitch of the IDT electrode in the direction orthogonal or substantially orthogonal to the electrode finger extending direction.

7. The acoustic wave device according to claim 6, wherein some of the plurality of first non-formation regions are arranged at a period that is an integer multiple of the electrode finger pitch of the IDT electrode in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, and others of the plurality of first non-formation regions are arranged in the electrode finger extending direction; and when a first imaginary line is defined as an imaginary line extending in the direction orthogonal or substantially orthogonal to the electrode finger extending direction and passing through a midpoint between first non-formation regions of the plurality of non-formation regions adjacent to each other in the electrode finger extending direction, the plurality of first non-formation regions are not located on any of the first imaginary lines.

8. The acoustic wave device according to claim 1, wherein some of the plurality of first non-formation regions are arranged in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, and others of the plurality of first non-formation regions are arranged in the electrode finger extending direction; and when a first imaginary line is defined as an imaginary line extending in the direction orthogonal or substantially orthogonal to the electrode finger extending direction and passing through a midpoint between first non-formation regions of

the plurality of first non-formation regions adjacent to each other in the electrode finger extending direction, the plurality of the first non-formation regions that are arranged in the direction orthogonal to the electrode finger extending direction are located on the first imaginary line.
9. The acoustic wave device according to claim 8, wherein, when a second imaginary line is defined as an imaginary line extending in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, passing through a midpoint between two of the plurality of first non-formation regions adjacent to each other in the electrode finger extending direction, and extending from one end to another end of the crossing region in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, a first length L**1** is defined as a total length of portions where the plurality of first non-formation regions are located on one of second imaginary lines, a second length L**2** is defined as a total length of portions where the plurality of first non-formation regions not located on one of the second imaginary lines, and Rmax is defined as a maximum value and Rmin is defined as a minimum value of a ratio L**1**/L**2** between the first length L**1** and the second length L**2** for all of the second imaginary lines, (Rmax−Rmin)/Rmin is about 1.25 or less.
10. The acoustic wave device according to claim 9, wherein, when a third imaginary line is defined as an imaginary line extending in the direction orthogonal or substantially orthogonal to the electrode finger extending direction and extending from one end to another end of the crossing region in the direction orthogonal or substantially orthogonal to the electrode finger extending direction, a third length L**3** is defined as a total length of portions where the plurality of first non-formation regions are located on one of the third imaginary lines, a fourth length L**4** is defined as a total length of portions where the plurality of first non-formation regions are not located on one of the third imaginary lines, and a uniform portion is defined as a portion where the third imaginary line such that a ratio L**3**/L**4** between the third length L**3** and the fourth length L**4** is about 1 time or less of the maximum value Rmax and about 1 time or greater of the minimum value Rmin is located, the crossing region includes at least one of the uniform portions; and a total area of all uniform portions is about 80% or greater of an area of the crossing region.
11. The acoustic wave device according to claim 1, wherein an entirety or substantially an entirety of the plurality of first non-formation regions overlaps in plan view a portion between the plurality of electrode fingers.
12. The acoustic wave device according to claim 1, further comprising: a pair of reflectors on the first main surface of the piezoelectric substrate facing each other with the IDT electrode therebetween in the direction orthogonal or substantially orthogonal to the electrode finger extending direction and each of which includes a plurality of reflector electrode fingers; and at least one second electrode layer between the support substrate and the piezoelectric layer, not connected to a signal potential, and overlapping the reflectors in plan view; wherein a region where the plurality of reflector electrode fingers adjacent to each other overlap when each of the reflectors is seen from the direction orthogonal or substantially orthogonal to the electrode finger extending direction is a reflector crossing region of each of the reflectors; the piezoelectric substrate includes a second formation region overlapping the reflector crossing region and overlapping the second electrode layer in plan view and a second non-formation region overlapping the reflector crossing region and not overlapping the second electrode layer in plan view; and the second non-formation region overlaps in plan view at least one of portions between the plurality of reflector electrode fingers that are adjacent to each other.
13. The acoustic wave device according to claim 12, wherein the first electrode layer and the second electrode layer are not connected.
14. The acoustic wave device according to claim 1, wherein the piezoelectric substrate includes a dielectric layer between the piezoelectric layer and the first electrode layer.
15. The acoustic wave device according to claim 1, wherein the piezoelectric substrate includes an intermediate layer between the piezoelectric layer and the support substrate; and a portion of the

intermediate layer is located between the first electrode layer and the support substrate.

16. The acoustic wave device according to claim 1, wherein a hollow portion is provided in the piezoelectric substrate; and the first electrode layer is provided in the hollow portion.

17. The acoustic wave device according to claim 1, further comprising at least one third electrode layer between the support substrate and the piezoelectric layer and not overlapping the crossing region in plan view.

18. The acoustic wave device according to claim 17, further comprising: at least one wiring line on the first main surface of the piezoelectric layer; wherein the at least one wiring line includes a first wiring line connected to the IDT electrode; and the third electrode layer overlaps the first wiring line in plan view.

19. The acoustic wave device according to claim 18, further comprising: a plurality of the third electrode layers; and a plurality of the wiring lines; wherein the plurality of wiring lines include a second wiring line connected to a potential different from a potential to which the first wiring line is connected; and the plurality of third electrode layers include two of the third electrode layers not in contact with each other, one of the two third electrode layers not in contact with each other overlaps the first wiring line in plan view, and another of the two third electrode layers not in contact with each other overlaps the second wiring line in plan view.