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(54) **ULTRASONIC DEVICE, ULTRASONIC
PROBE, ELECTRONIC APPARATUS, AND
ULTRASONIC IMAGING APPARATUS**

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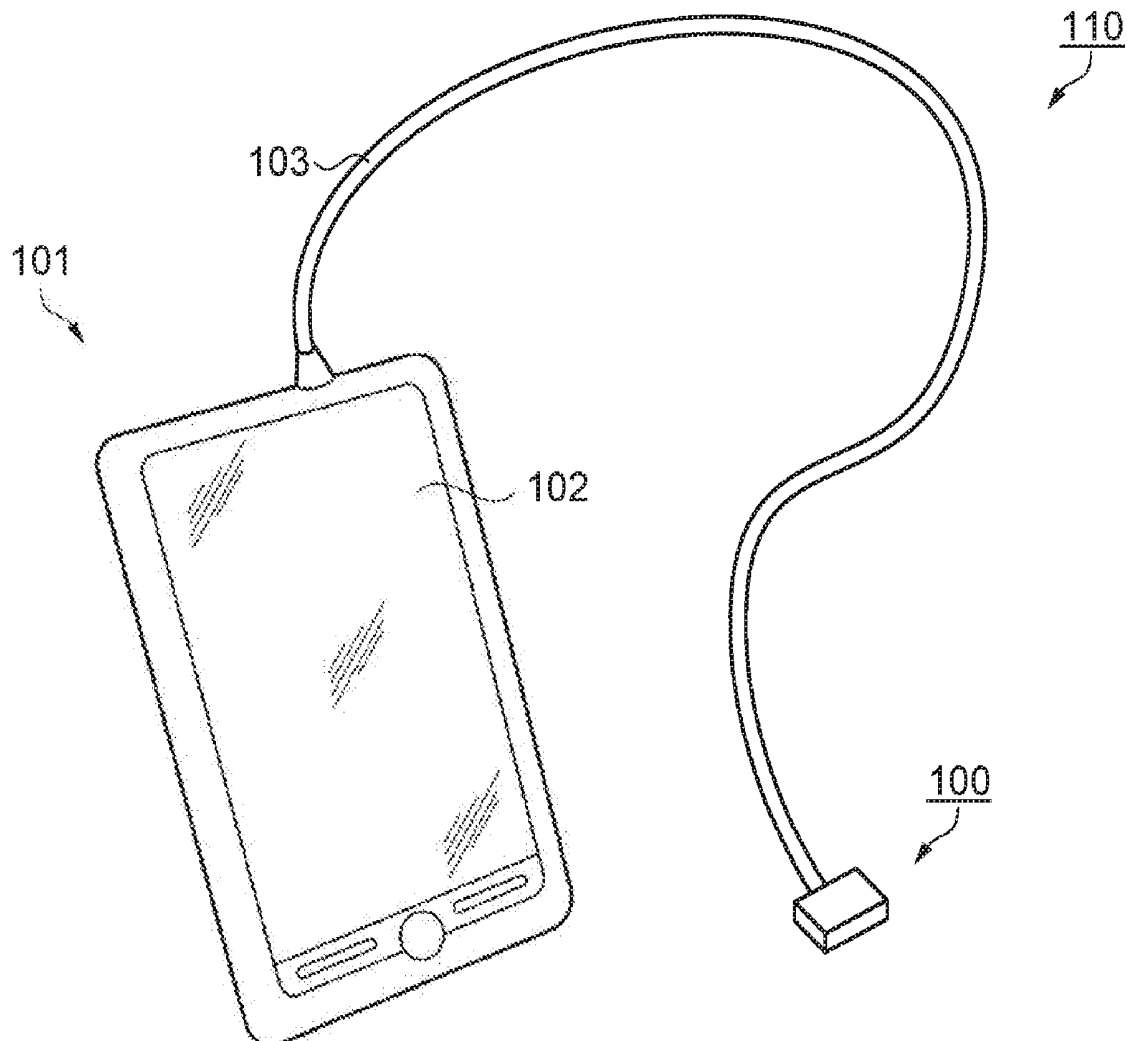
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ABSTRACT

An ultrasonic device that transmits and receives ultrasonic waves includes: ultrasonic elements including first and second surfaces from which the ultrasonic waves are emitted; and a backing unit that supports the second surfaces of the ultrasonic elements and attenuates the ultrasonic waves emitted to the second surface side. The backing unit has slits inclined in a thickness direction. The ultrasonic elements are arranged in the shape of an array, and the slits are arranged at distances equal to an arrangement distance between the ultrasonic elements arranged in the shape of an array.



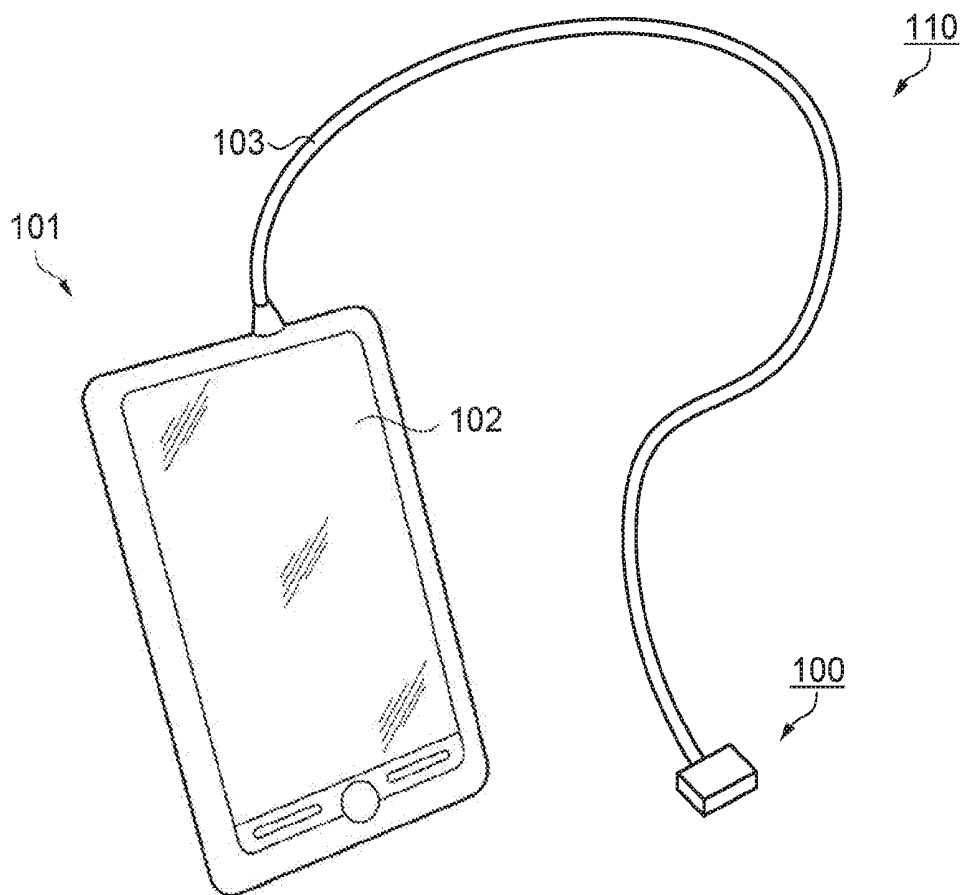


FIG. 1

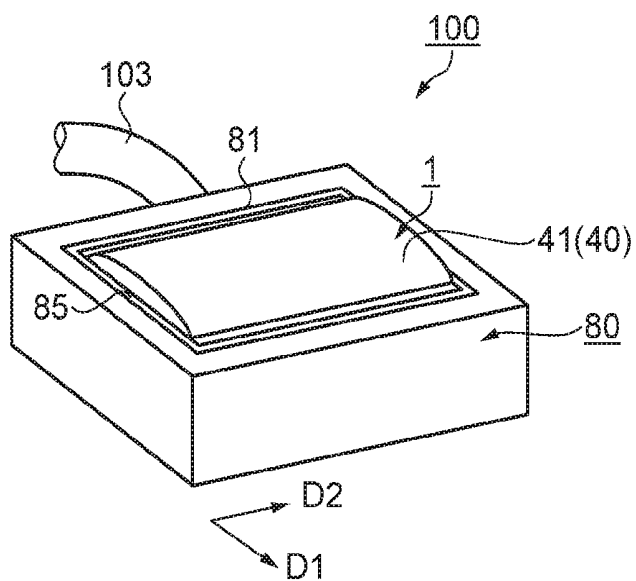


FIG. 2

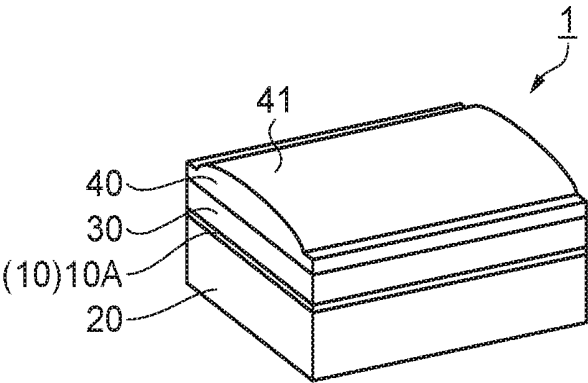


FIG. 3

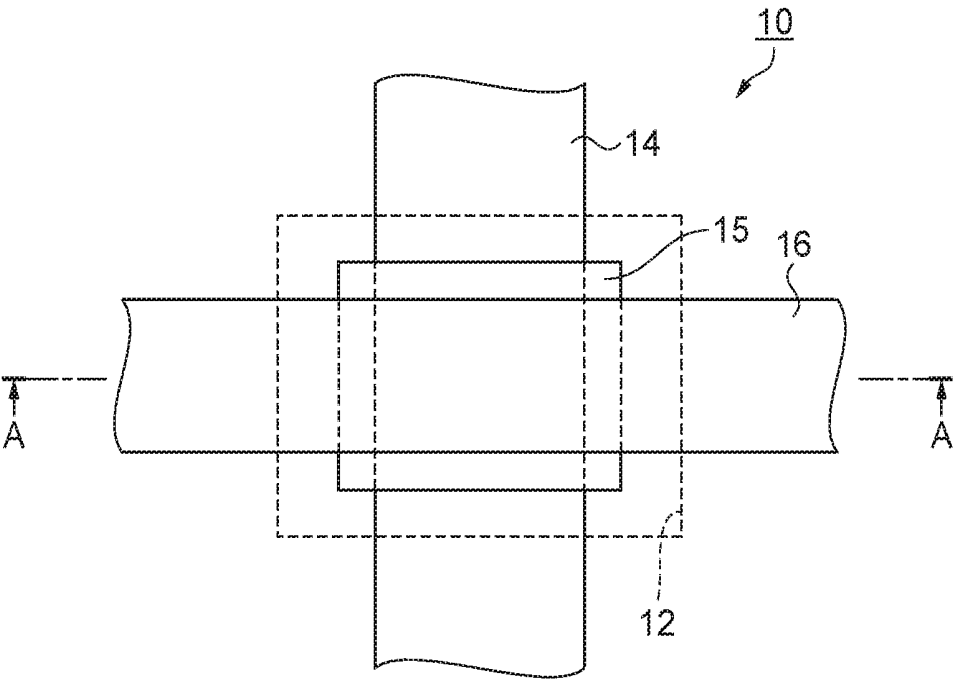


FIG. 4

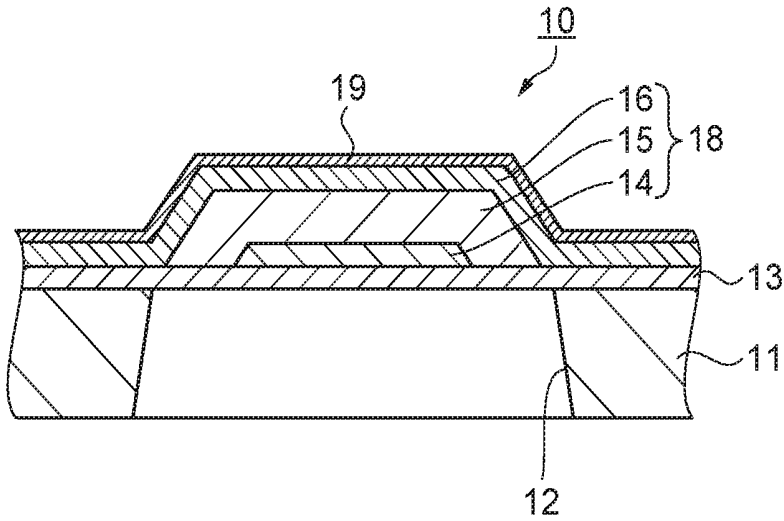


FIG. 5

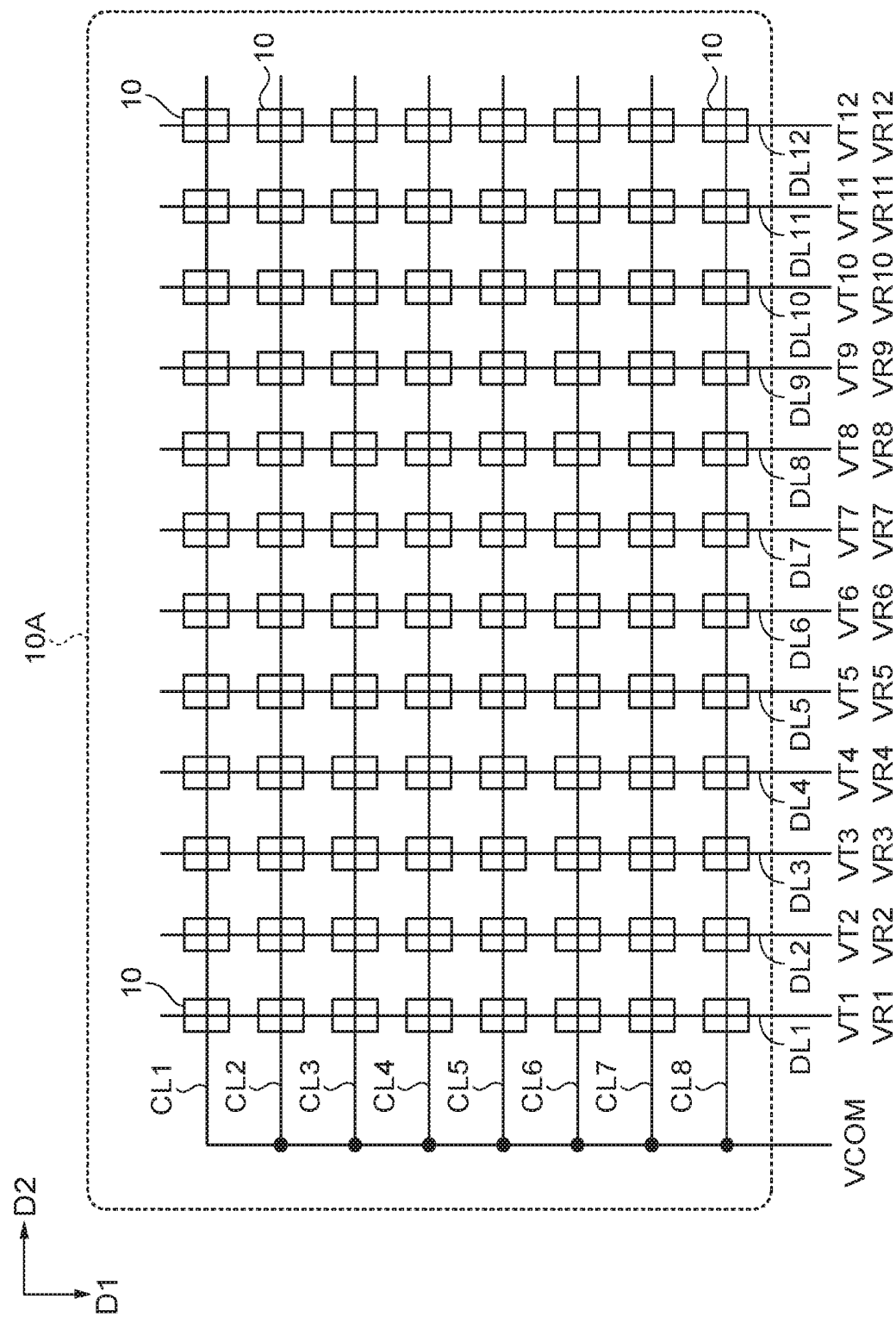


FIG. 6

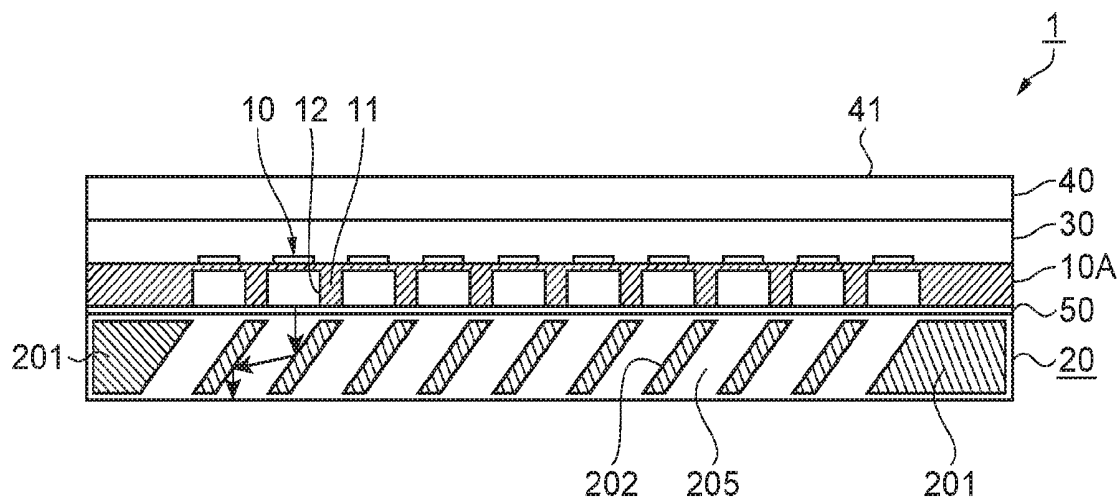


FIG. 7

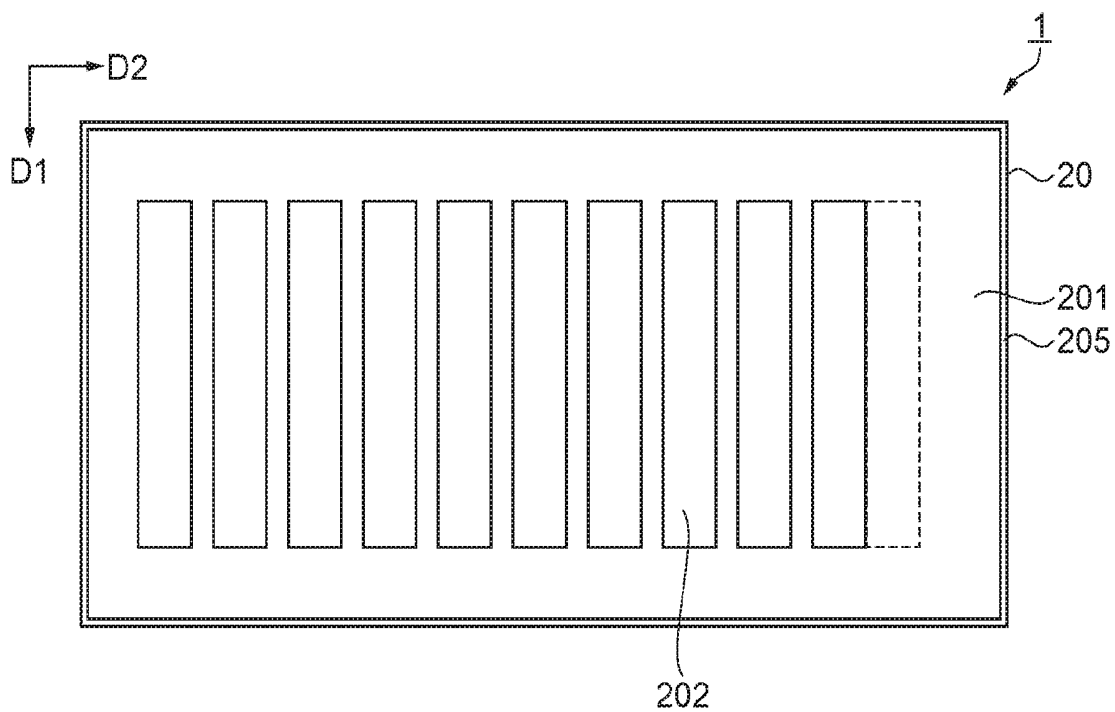


FIG. 8

FIG. 10

**ULTRASONIC DEVICE, ULTRASONIC
PROBE, ELECTRONIC APPARATUS, AND
ULTRASONIC IMAGING APPARATUS**

[0001] This application claims the benefit of Japanese Patent Application No. 2015-212630, filed on Oct. 29, 2015. The content of the aforementioned application is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] 1. Technical Field

[0003] The present invention relates to an ultrasonic device, an ultrasonic probe including an ultrasonic device, and an electronic apparatus including an ultrasonic probe, and an ultrasonic imaging apparatus including an ultrasonic probe.

[0004] 2. Related Art

[0005] A known ultrasonic device is configured to include a piezoelectric member, a backing unit, an acoustic matching layer, an acoustic lens, and the like. Ultrasonic waves generated by the piezoelectric member of the ultrasonic device are incident on a subject through the acoustic matching layer and the acoustic lens. Then, the ultrasonic device receives reflected waves (ultrasonic waves) that are reflected from the inside of the subject, and generates a voltage corresponding to the strength of the reflected waves. In addition, the backing unit supports the piezoelectric member and attenuates unwanted ultrasonic waves, thereby suppressing noise riding on the ultrasonic wave incident on the subject.

[0006] In a case where the piezoelectric member (ultrasonic element) is formed in a thin-film structure in which a piezoelectric layer is arranged in the shape of an array on a vibrating film on a silicon substrate, a metal plate is used as a backing member that forms the backing unit in order to secure the structural strength including the rigid force of suppressing deflection of the ultrasonic element array. In addition, since the backing member uses a characteristic that the attenuation of ultrasonic waves increases as the travel distance increases (thickness increases), a metal plate having a thickness equal to or greater than the rigid force is used.

[0007] JP-A-2007-134767 discloses an ultrasonic probe configured to include piezoelectric transducers arranged on a backing material. In the ultrasonic probe disclosed in JP-A-2007-134767, a backing material is formed of a composite material containing a fiber material and a resin, and the longitudinal direction of the fiber material matches a vibration direction of each piezoelectric transducer. JP-A-2007-134767 discloses that lightness and broadband frequency characteristics are realized to obtain a high-quality image by using such an ultrasonic probe. In addition, in the ultrasonic probe disclosed in JP-A-2007-134767, the piezoelectric transducer is of a so-called bulk type. Accordingly, as a backing material, for example, by dispersing tungsten powder slightly in a composite material containing an epoxy resin and carbon fiber, lightness is realized.

[0008] Currently, in order to improve the convenience of the ultrasonic probe or the ultrasonic imaging apparatus, it has been requested to make an ultrasonic device thin using a thin-film ultrasonic element (ultrasonic element array). Specifically, it has been requested to make a backing unit thin. In the case of simply reducing the thickness of the backing member in the related art, it is a problem that unwanted ultrasonic waves, which have not been attenuated

by the backing member, are emitted to the ultrasonic element side to become a large noise component. In addition, since the noise component is displayed as artifacts in the Y-axis direction (depth direction) during B-mode imaging, the noise component is the cause of false findings in an examination or the like.

[0009] Therefore, an ultrasonic device including a backing unit that can suppress unwanted ultrasonic waves and can be made thin, an ultrasonic probe including the ultrasonic device, an electronic apparatus including the ultrasonic probe, and an ultrasonic imaging apparatus including the ultrasonic probe have been demanded.

SUMMARY

[0010] An advantage of some aspects of the invention is to solve at least a part of the problems described above, and the invention can be implemented as the following aspects or application examples.

Application Example 1

[0011] An ultrasonic device according to this application example transmits and receives ultrasonic waves. The ultrasonic device includes: ultrasonic elements including first and second surfaces from which the ultrasonic waves are emitted; and a backing unit that supports the second surfaces of the ultrasonic elements and attenuates the ultrasonic waves emitted to the second surface side. The backing unit has slits inclined in a thickness direction.

[0012] According to such an ultrasonic device, the backing unit that supports the second surface of each ultrasonic element includes the slits inclined in the thickness direction. Therefore, in a case where the ultrasonic wave emitted from the second surface side of the ultrasonic element is incident on the inside of the inclined slit, the ultrasonic wave travels while being repeatedly reflected by the inner wall (boundary surface) of the slit. Thus, by increasing the travel path (travel distance) using the reflection, it is possible to attenuate the ultrasonic wave. Then, in a case where the ultrasonic wave having traveled through the backing unit returns to the ultrasonic element, for example, by total reflection, the ultrasonic wave returns while being reflected in the reverse path in traveling through the slit of the backing unit. Accordingly, it is possible to suppress unwanted ultrasonic waves returning to the ultrasonic element from the backing unit. Thus, it is possible to prevent the ultrasonic wave emitted from the second surface side from riding, as noise, on the ultrasonic wave emitted from the first surface side. In addition, compared with the thickness of a backing unit in the related art, the backing unit can be made thin up to the minimum thickness at which the structural strength of the ultrasonic element and the slit capable of suppressing unwanted ultrasonic waves can be secured. As a result, it is possible to realize the ultrasonic device that can suppress unwanted ultrasonic waves and can be made thin.

Application Example 2

[0013] In the ultrasonic device according to the application example, it is preferable that the ultrasonic elements are arranged in a shape of an array.

[0014] According to such an ultrasonic device, also in a case where the ultrasonic elements are arranged in the shape of an array, it is possible to increase the travel distance by making the ultrasonic wave travel while repeating reflection

on the inner wall of each slit. Therefore, it is possible to attenuate the ultrasonic wave. Accordingly, it is possible to suppress unwanted ultrasonic waves returning to each ultrasonic element from the backing unit. In addition, compared with the thickness of a backing unit in the related art, the backing unit can be made thin up to the minimum thickness at which the structural strength for preventing the deflection of ultrasonic elements arranged in the shape of an array (ultrasonic element array) and the slit capable of suppressing unwanted ultrasonic waves can be secured. As a result, it is possible to realize the ultrasonic device that can suppress unwanted ultrasonic waves and can be made thin.

Application Example 3

[0015] In the ultrasonic device according to the application example, it is preferable that the slits are arranged at distances equal to an arrangement distance between the ultrasonic elements arranged in the shape of an array.

[0016] According to such an ultrasonic device, ultrasonic waves emitted from the ultrasonic elements can be made to be efficiently incident on the corresponding slits by arranging the slits at distances equal to the arrangement distance between the ultrasonic elements arranged in the shape of an array. Therefore, since it is possible to efficiently arrange the slits, it is possible to suppress unwanted ultrasonic waves returning to the ultrasonic element from the backing unit. As a result, the backing unit can be made thinner.

Application Example 4

[0017] In the ultrasonic device according to the application example, it is preferable that the backing unit is superimposed in the thickness direction.

[0018] According to such an ultrasonic device, since the backing unit is superimposed in the thickness direction, the ultrasonic wave can travel while being repeatedly reflected by the slit of the superimposed backing unit. Therefore, it is possible to further attenuate the ultrasonic wave. Accordingly, it is possible to further suppress unwanted ultrasonic waves returning to each ultrasonic element from the backing unit.

Application Example 5

[0019] In the ultrasonic device according to the application example, it is preferable that the backing unit is coated with a coating material.

[0020] According to such an ultrasonic device, it is possible to prevent the generation of an air layer between the ultrasonic element and the backing unit. For example, in a case where a resin is used as a coating material, it is possible to approximately match the acoustic impedance of the coating material with the acoustic impedance of the ultrasonic element. Therefore, ultrasonic waves emitted from the ultrasonic element can be made to be efficiently incident on the backing unit while suppressing reflection on the boundary surface of the backing unit. In addition, since the generation of an air layer inside the slit is prevented, it is possible to efficiently transmit reflected ultrasonic waves. Accordingly, it is possible to suppress unwanted ultrasonic waves returning to the ultrasonic element from the backing unit.

Application Example 6

[0021] An ultrasonic probe according to this application example includes the ultrasonic device according to any one of the application examples: and a housing member that houses the ultrasonic device such that apart of the ultrasonic device is exposed.

[0022] According to such an ultrasonic probe, since the ultrasonic probe is configured such that a thin ultrasonic device is housed in the housing member, it is possible to make the ultrasonic probe thin. In addition, since the ultrasonic device for suppressing unwanted ultrasonic waves is housed, it is possible to prevent unwanted ultrasonic waves from riding as noise on the ultrasonic waves emitted toward the subject from the ultrasonic device. Therefore, it is possible to improve the quality of the ultrasonic probe.

Application Example 7

[0023] An electronic apparatus according to this application example includes: the ultrasonic probe described above; and a processing device that controls the ultrasonic probe and processes an input signal from the ultrasonic probe.

[0024] According to such an electronic apparatus, it is possible to improve the convenience and quality of the electronic apparatus due to the ultrasonic probe, which is made thin and has improved quality, and the processing device.

Application Example 8

[0025] An ultrasonic imaging apparatus according to this application example includes: the ultrasonic probe described above; a processing device that controls the ultrasonic probe and generates an image by processing an input signal from the ultrasonic probe; and a display device that displays the image generated by the processing device.

[0026] According to such an ultrasonic imaging apparatus, it is possible to improve the convenience of the ultrasonic imaging apparatus by using the thin ultrasonic probe, the processing device, and the display device. In addition, since the ultrasonic probe (ultrasonic device) that suppresses unwanted ultrasonic waves is provided, the ultrasonic imaging apparatus can suppress the occurrence of artifacts during B-mode imaging. Therefore, it is possible to reduce false findings in an examination or the like. As a result, it is possible to improve the quality of the ultrasonic imaging apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

[0028] FIG. 1 is a perspective view showing the schematic configuration of an ultrasonic imaging apparatus according to a first embodiment.

[0029] FIG. 2 is a perspective view showing the schematic configuration of an ultrasonic probe.

[0030] FIG. 3 is a perspective view showing the schematic configuration of an ultrasonic device.

[0031] FIG. 4 is a plan view showing the schematic configuration of an ultrasonic element.

[0032] FIG. 5 is a sectional view showing the schematic configuration of an ultrasonic element.

[0033] FIG. 6 is an explanatory view showing the schematic configuration of an ultrasonic element array.

[0034] FIG. 7 is a sectional view showing the configuration of an ultrasonic device.

[0035] FIG. 8 is a plan view when the ultrasonic device is viewed from a backing unit side.

[0036] FIG. 9 is a sectional view showing the configuration of an ultrasonic device according to a second embodiment.

[0037] FIG. 10 is a sectional view showing the configuration of an ultrasonic device according to a third embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0038] In the present embodiment, an ultrasonic device 1, an ultrasonic probe 100 including the ultrasonic device 1, and an ultrasonic imaging apparatus 110 as an electronic apparatus including the ultrasonic probe 100 will be described with reference to the accompanying diagrams. In each diagram, the scale of each member is adjusted in order to have a recognizable size.

First Embodiment

[0039] FIG. 1 is a perspective view showing the schematic configuration of the ultrasonic imaging apparatus 110 according to the first embodiment. The configuration of the ultrasonic imaging apparatus 110 will be described with reference to FIG. 1.

[0040] The ultrasonic imaging apparatus 110 of the present embodiment is an apparatus that holds the ultrasonic probe 100 on the skin surface of a subject or the like so as to be in close contact with each other, transmits ultrasonic waves from the ultrasonic probe 100, receives reflected waves (ultrasonic waves) that are reflected from the inside of the subject, analyzes data of the received ultrasonic waves, and displays the data as an image. An operator performs an insertion operation or the like while checking the image.

[0041] The ultrasonic imaging apparatus 110 as an electronic apparatus includes the ultrasonic probe 100, a processing device 101, and a display device 102. The ultrasonic probe 100 and the processing device 101 are connected to each other through a flexible cable 103, so that an electrical signal is transmitted or received therebetween. The processing device 101 includes the display device 102, and displays an image generated by the processing of the processing device 101 (image based on ultrasonic waves detected by the ultrasonic probe 100).

[0042] FIG. 2 is a perspective view showing the schematic configuration of the ultrasonic probe 100. Specifically, FIG. 2 is a perspective view when the ultrasonic probe 100 is viewed from a side on which the ultrasonic probe 100 is in close contact with the skin surface. FIG. 3 is a perspective view showing the schematic configuration of the ultrasonic device 1. The configurations of the ultrasonic probe 100 and the ultrasonic device 1 will be described with reference to FIGS. 2 and 3.

[0043] As shown in FIG. 2, the ultrasonic probe 100 of the present embodiment is configured to include the ultrasonic device 1, a housing member 80, and the like. The ultrasonic device 1 is generally formed in the shape of a rectangular flat plate, as shown in FIG. 3. Similar to the ultrasonic device 1, the housing member 80 is also formed in the shape of a

rectangular flat plate. The housing member 80 has a housing unit 81, and houses the ultrasonic device 1 therein in a state in which an acoustic lens 40 (lens unit 41), which is a part of the ultrasonic device 1, is exposed. When housing the ultrasonic device 1 in the housing unit 81, a gap between the housing unit 81 and the ultrasonic device 1 is sealed by inserting a silicone-based sealing member 85 to a gap between the inner surface of the housing unit 81 and the outer surface of the ultrasonic device 1. The housing member 80 is formed using a synthetic resin member in the present embodiment. However, other members, for example, a metal member can be used without being limited thereto.

[0044] As shown in FIG. 3, the ultrasonic device 1 of the present embodiment is configured to include an acoustic matching layer 30, the acoustic lens 40, and a backing unit 20 that are provided above and below an ultrasonic element array 10A (ultrasonic element 10) formed in a rectangular shape. Ultrasonic waves generated by the ultrasonic element 10 of the ultrasonic device 1 are incident on a subject through the acoustic matching layer 30 and the acoustic lens 40. Then, the ultrasonic device 1 receives reflected waves (echo waves) that are reflected from the inside of the subject, and generates a voltage corresponding to the strength of the echoes.

[0045] The acoustic matching layer 30 performs acoustic matching for making ultrasonic waves incident on the inside of the subject efficiently by suppressing the reflection of the ultrasonic waves by reducing the difference in acoustic impedance between the ultrasonic element array 10A and the subject. The acoustic lens 40 has an outer surface that is convex in a thickness direction, as shown in FIGS. 2 and 3. Thus, the acoustic lens 40 includes the lens unit 41 that is formed in a partially cylindrical shape. The curvature of the lens unit 41 is set according to the focal position of ultrasonic waves. The acoustic lens 40 improves the resolution by converging the spread of ultrasonic waves emitted from the ultrasonic element array 10A using the lens unit 41. In addition, the backing unit 20 improves the distance resolution in an image by attenuating unwanted ultrasonic waves emitted from the ultrasonic element array 10A.

[0046] As shown in FIG. 2, a scan direction D2 is defined as a direction parallel to the generatrix of the acoustic lens 40, and a slice direction D1 is defined as a direction that is perpendicular to the generatrix of the acoustic lens 40 and is parallel to the surface of the housing member 80 in which the housing unit 81 is formed. The scan direction D2 and the slice direction D1 are perpendicular to each other within this plane.

[0047] FIG. 4 is a plan view showing the schematic configuration of the ultrasonic element 10. FIG. 5 is a sectional view showing the schematic configuration of the ultrasonic element 10. FIG. 5 is a sectional view taken along the line A-A of FIG. 4. FIG. 6 is an explanatory view showing the schematic configuration of the ultrasonic element array 10A. The configurations of the ultrasonic element 10 and the ultrasonic element array 10A of the present embodiment will be described with reference to FIGS. 4 to 6. The ultrasonic element 10 of the present embodiment is a thin-film piezoelectric element.

[0048] As shown in FIGS. 4 and 5, the ultrasonic element 10 includes a base substrate 11, a vibrating film 13 formed on the base substrate 11, and a piezoelectric portion 18

provided on the vibrating film 13. The piezoelectric portion 18 includes a first electrode 14, a piezoelectric layer 15, and a second electrode 16.

[0049] In the ultrasonic element 10, an opening 12 is provided in the base substrate 11 formed of silicon or the like, and the vibrating film 13 is provided so as to cover and seal the opening 12. The opening 12 is formed by etching, such as reactive ion etching (RIE), from the back surface (surface on which no element is formed) side of the base substrate 11. For example, the vibrating film 13 is formed as a two-layer structure including a silicon oxide (SiO_2) layer and a zirconium oxide (ZrO_2) layer. Here, in a case where the base substrate 11 is a silicon substrate, the silicon oxide layer can be formed by performing thermal oxidation processing on the substrate surface. The zirconium oxide layer is formed on the silicon oxide layer using a sputtering method, for example. Here, in the case of using, for example, lead zirconate titanate (PZT) as the piezoelectric layer 15 to be described later, the zirconium oxide layer is a layer for preventing the lead forming the PZT from diffusing into the silicon oxide layer. The zirconium oxide layer also has an effect of improving the deflection efficiency against the distortion of the piezoelectric layer 15.

[0050] The first electrode 14 is formed on the upper surface of the vibrating film 13, the piezoelectric layer 15 is formed on the upper surface of the first electrode 14, and the second electrode 16 is formed on the upper surface of the piezoelectric layer 15. In other words, the piezoelectric portion 18 is formed in a structure in which the piezoelectric layer 15 is interposed between the first electrode 14 and the second electrode 16.

[0051] In a case where the first electrode 14 is formed using a metal thin film and includes a plurality of ultrasonic elements 10 (piezoelectric layer 15), the first electrode 14 may be a wiring line that extends to the outside of the element forming region to be connected to the ultrasonic element 10 (piezoelectric layer 15), as shown in FIG. 4.

[0052] The piezoelectric layer 15 is formed using, for example, a lead zirconate titanate (PZT) thin film, and is provided so as to cover at least a part of the first electrode 14. The material of the piezoelectric layer 15 is not limited to the PZT. For example, lead titanate (PbTiO_3), lead zirconate (PbZrO_3), lead lanthanum titanate ($(\text{Pb}, \text{La}) \text{TiO}_3$) may be used.

[0053] The second electrode 16 is formed using a metal thin film, and is provided so as to cover at least a part of the piezoelectric layer 15. In a case where the second electrode includes a plurality of ultrasonic elements 10 (piezoelectric layer 15), the second electrode 16 may be a wiring line that extends to the outside of the element forming region to be connected to the adjacent ultrasonic element 10 (piezoelectric layer 15), as shown in FIG. 4.

[0054] In addition, as shown in FIG. 5, a moisture-proof layer 19 that covers the ultrasonic element 10 in order to block moisture from the outside is provided. This moisture-proof layer 19 is formed of a material, such as alumina, and is provided on the entire surface of the ultrasonic element 10 or on a part thereof. The moisture-proof layer 19 may be appropriately set depending on the conditions or environment of use, or the moisture-proof layer 19 may not be provided.

[0055] The piezoelectric layer 15 expands and contracts in the in-plane direction when a voltage is applied between the first electrode 14 and the second electrode 16. Therefore,

when a voltage is applied to the piezoelectric layer 15, for example, bending that causes to become convex on the opening 12 side occurs to deflect the vibrating film 13. By applying an AC voltage to the piezoelectric layer 15, the vibrating film 13 vibrates in a thickness direction, and ultrasonic waves are emitted from the opening 12 by the vibration of the vibrating film 13. In addition, ultrasonic waves are emitted to the opposite side (element formation side) to the opening 12. In addition, the ultrasonic device 1 of the present embodiment emits the ultrasonic waves, which are emitted to the opposite side (element formation side) to the opening 12, to the subject. The voltage (driving voltage) applied to the piezoelectric layer 15 is, for example, 10 to 30 V (peak-to-peak value). The frequency is, for example, 1 to 10 MHz.

[0056] The ultrasonic element 10 also operates as a reception element that receives echo waves, which return due to reflection on the object, of the emitted ultrasonic waves. The vibrating film 13 is vibrated by echo waves. Due to this vibration, stress is applied to the piezoelectric layer 15 to generate a voltage between the first electrode 14 and the second electrode 16. This voltage can be taken out as a reception signal.

[0057] Next, the ultrasonic element array 10A in which the ultrasonic elements 10 described above are arranged in the shape of an array will be described with reference to FIG. 6. The ultrasonic element array 10A includes a plurality of ultrasonic elements 10 arranged in the shape of an array, a driving electrode line DL, and a common electrode line CL. A plurality of ultrasonic elements 10 are arranged in a matrix of m rows and n columns. In FIG. 6, as an example, eight rows of ultrasonic elements are arranged in the slice direction D1, and twelve columns of ultrasonic elements are arranged in the scan direction D2.

[0058] Each of driving electrode lines DL1 to DL12 is wired along the slice direction D1. During a transmission period for which ultrasonic waves are transmitted, transmission signals VT1 to VT12 output from a processing circuit (not shown) forming the processing device 101 are supplied to the ultrasonic elements 10 through the driving electrode lines DL1 to DL12. In addition, during a reception period for which echo signals of the ultrasonic waves are received, reception signals VR1 to VR12 from the ultrasonic elements 10 are output to the processing circuit through the driving electrode lines DL1 to DL12.

[0059] Each of common electrode lines CL1 to CL8 is wired along the scan direction D2. A common voltage VCOM is supplied to the common electrode lines CL1 to CL8. The common voltage VCOM may be a fixed DC voltage, and may not be 0 V, that is, a ground potential.

[0060] During the transmission period, a voltage corresponding to the difference between the transmission signal voltage and the common voltage is applied to each ultrasonic element 10, and an ultrasonic wave having a predetermined frequency is emitted. The arrangement of the ultrasonic elements 10 is not limited to the matrix arrangement of eight rows and twelve columns shown in FIG. 6.

[0061] FIG. 7 is a sectional view showing the configuration of the ultrasonic device 1. Specifically, FIG. 7 is a sectional view when the ultrasonic device 1 is cut in the scan direction D2. FIG. 8 is a plan view when the ultrasonic device 1 is viewed from the backing unit 20 side. In FIG. 8, a backing member 201 coated with a coating material 205 is shown in solid lines for convenience of explanation. In

addition, the number of ultrasonic elements **10** in the scan direction **D2** is 10 for convenience of explanation. The configuration of the ultrasonic device **1** will be described with reference to FIGS. **3**, **7**, and **8**.

[0062] As described above, the ultrasonic device **1** is configured to include the acoustic matching layer **30**, the acoustic lens **40**, and the backing unit **20** that are provided above and below the ultrasonic element array **10A** (ultrasonic element **10**) formed in a rectangular shape. In the present embodiment, the acoustic matching layer **30** is formed on the element forming surface (first surface) of the ultrasonic element array **10A**, and the acoustic lens **40** is formed on the acoustic matching layer **30**. The backing unit **20** that supports the ultrasonic element array **10A** is formed on a surface (second surface) opposite the element forming surface of the ultrasonic element array **10A**.

[0063] The acoustic lens **40** is formed of a resin, such as a silicone resin. As shown in FIG. **3**, the lens unit **41** of the acoustic lens **40** is provided so as to cover a range corresponding to the ultrasonic element **10** that forms the ultrasonic element array **10A**.

[0064] The acoustic matching layer **30** is formed between the ultrasonic element array **10A** and the acoustic lens **40**. As the acoustic matching layer **30**, silicone-based adhesive is used. The adhesive is cured to fix (bond) the ultrasonic element array **10A** and the acoustic lens **40**. The cured adhesive (resin) functions as the acoustic matching layer **30**. The acoustic matching layer **30** reduces mismatching of acoustic impedance between the ultrasonic element **10** and the acoustic lens **40**.

[0065] In the ultrasonic element array **10A**, a silicone resin is filled into the opening **12** formed in the base substrate **11**, and is then cured. Accordingly, the ultrasonic element array **10A** is in a state in which the opening **12** is filled with the silicone resin. As a result, in a case where the ultrasonic element array **10A** is bonded to the backing unit **20** to be described later, the generation of an air layer in the opening **12** is prevented.

[0066] The backing unit **20** is formed using a backing member **201**. In addition, the backing member **201** is coated with the coating material **205**. In the present embodiment, the backing member **201** is formed using a stainless member that is a rectangular plate-shaped metal member. As the backing member **201**, a metal member or a ceramic member other than the stainless member may be used.

[0067] The backing member **201** has slits **202** that are inclined in the thickness direction. In the present embodiment, each slit **202** is formed corresponding to the ultrasonic element **10**. In addition, the slit **202** is formed so as to extend in the slice direction **D1**. A plurality of slits **202** corresponding to the number of ultrasonic elements **10** aligned in the scan direction **D2** are formed in the scan direction **D2** at distances (itches) equal to the arrangement distance between the ultrasonic elements **10**. The hole diameter of the slit **202** in the planar direction (hole diameter of the slit **202** in the lateral direction) is the same as the diameter of the opening **12** of the ultrasonic element array **10A** (base substrate **11**). In addition, the hole diameter may be larger than the diameter of the opening **12**.

[0068] In the present embodiment, the slit **202** is formed by laser machining. Specifically, the slit **202** is formed by laser machining using a so-called picosecond laser (short-pulse laser). The picosecond laser is a laser having a pulse width, which indicates the irradiation time of laser, in a

picosecond region. Since the irradiation time is short, a region around the machining area is hardly affected by heat, and burrs due to dissolution are hard to occur. Accordingly, it is possible to perform high-density hole machining with high accuracy.

[0069] The entire backing member **201** in which the slits **202** are formed is coated with the coating material **205**. In the present embodiment, a resin, such as a silicone resin, is used as the coating material **205**. For the coating, the backing member **201** is placed in a container as a jig for coating, a silicone resin is poured into the container, and the silicone resin is cured in a state in which the entire backing member **201** is coated. Accordingly, in the backing member **201**, the inside of the slit **202** and the outer peripheral portion of the backing member **201** are coated. Thus, the backing unit **20** is completed.

[0070] In the present embodiment, a silicone resin is used as the coating material **205**. However, other synthetic resins, such as an ABS resin having approximately the same acoustic impedance as the ultrasonic element **10** may be used. In the case of using a synthetic resin, such as an ABS resin, the backing unit **20** may be molded by coating (molding) the entire backing member **201**, for example, by performing injection molding using an injection molding machine. In the present embodiment, the acoustic impedance of the ultrasonic element **10** is about 1 MRayl.

[0071] The backing unit **20** configured as described above is aligned, and is bonded to the ultrasonic element array **10A** with an adhesive layer **50** interposed therebetween. In the present embodiment, a so-called double-sided tape is used as the adhesive layer **50**.

[0072] Next, the operation of the backing unit **20** with respect to ultrasonic waves will be described. In FIG. **7**, the traveling direction of the ultrasonic wave is schematically shown by arrows.

[0073] The ultrasonic wave emitted from the ultrasonic element **10** is transmitted through the silicone resin, which is filled in the opening **12** and has approximately the same acoustic impedance as the ultrasonic element **10**, and is transmitted through the adhesive layer **50**. The ultrasonic wave transmitted through the adhesive layer **50** is incident on the backing unit **20**.

[0074] As described above, a silicone resin is used as the coating material **205** of the backing unit **20**, and the acoustic impedance of the silicone resin is approximately the same as the acoustic impedance of the ultrasonic element **10**. Therefore, the ultrasonic wave is incident on the backing unit (coating material **205**) since the reflection of the ultrasonic wave on the boundary surface of the coating is suppressed.

[0075] As shown by the arrows in FIG. **7**, the ultrasonic wave incident on the backing unit **20** travels to pass through the coating material **205** that fills the slit **202**. Then, the ultrasonic wave hits one inner wall of the inclined slit **202**. Since the acoustic impedance of the coating material **205** is greatly different from the acoustic impedance of the backing member **201**, the ultrasonic wave hitting the one inner wall of the slit **202** is reflected (approximately totally reflected) on the inner wall. The ultrasonic wave reflected by the one inner wall travels through the slit **202**, hits the other inner wall of the slit **202** again, and is similarly reflected. By repeating such reflection, the travel path (travel distance) of the ultrasonic wave becomes long. As a result, since the ultrasonic wave is diffused or scattered, the ultrasonic wave is attenuated.

[0076] The above operation with respect to the ultrasonic wave is performed at the slits 202 corresponding to all of the ultrasonic elements 10. Then, in a case where a portion above the backing unit 20 is an air layer and the ultrasonic wave reaching the end surface of the backing unit 20 is totally reflected finally, the ultrasonic wave travels through the slit 202 again while being repeatedly reflected in a path in an opposite direction to that described above. Due to such an operation, the ultrasonic wave returning to the ultrasonic element 10 is attenuated.

[0077] As shown in FIG. 8, the backing member 201 is formed using a rectangular metal member (stainless member), and is connected through the outer peripheral portion except for the slit 202 extending in the slice direction D1. In addition, the backing member 201 has a rigid force required to secure the structural strength for preventing the deflection of the ultrasonic element array 10A or the like.

[0078] In addition, the slit 202 is set to have an inclination angle and a length (thickness of the backing member 201), at which unwanted ultrasonic waves can be suppressed, while securing the structural strength (thickness) for preventing the deflection of the ultrasonic element array 10A or the like. In other words, the backing unit 20 is set to have a thickness at which the structural strength for preventing the deflection of the ultrasonic element array 10A or the like and the slit 202 capable of suppressing unwanted ultrasonic waves can be secured.

[0079] Although a metal member (stainless member) having a thickness of about 10 mm has been used as a backing unit (backing member) in the related art, a metal member (stainless member) having a thickness of about 5 mm to 8 mm can be used as the backing member 201 of the present embodiment.

[0080] According to the embodiment described above, the following effects are obtained.

[0081] According to the ultrasonic device 1 of the present embodiment, the backing unit 20 that supports the second surface (surface on the opposite side to the element forming surface) of the ultrasonic element 10 includes the slits 202 that are inclined in the thickness direction. Therefore, in a case where the ultrasonic wave emitted from the ultrasonic element 10 is incident on the inside of the inclined slit 202, the ultrasonic wave travels while being repeatedly reflected by the inner wall (boundary surface) of the slit 202. Thus, by increasing the travel path (travel distance) using the reflection in order to diffuse or scatter the ultrasonic wave, it is possible to attenuate the ultrasonic wave. Then, in a case where the ultrasonic wave having traveled through the backing unit 20 returns to the ultrasonic element 10, for example, by total reflection, the ultrasonic wave returns while being reflected in the reverse path in traveling through the slit 202 of the backing unit 20. Accordingly, it is possible to suppress unwanted ultrasonic waves returning to the ultrasonic element 10 from the backing unit 20. In the backing unit 20, a metal member (stainless member) or the like is used as the backing member 201. Accordingly, compared with the thickness of a backing unit in the related art, the backing unit 20 can be made thin up to the minimum thickness at which the structural strength of the ultrasonic element 10 and the slit 202 capable of suppressing unwanted ultrasonic waves can be secured. As a result, it is possible to realize the ultrasonic device 1 that can suppress unwanted ultrasonic waves and can be made thin.

[0082] According to the ultrasonic device 1 of the present embodiment, also in a case where the ultrasonic elements 10 are arranged in the shape of an array, it is possible to increase the travel distance by making the ultrasonic wave travel while repeating reflection on the inner wall of each slit 202. Therefore, it is possible to attenuate the ultrasonic wave. As a result, it is possible to suppress unwanted ultrasonic waves returning to each ultrasonic element 10 from the backing unit 20. In addition, in the backing unit 20, a metal member (stainless member) or the like is used as the backing member 201. Accordingly, compared with the thickness of a backing unit in the related art, the backing unit 20 can be made thin up to the minimum thickness at which the structural strength for preventing the deflection of the ultrasonic element array 10A or the like and the slit 202 capable of suppressing unwanted ultrasonic waves can be secured. As a result, it is possible to realize the ultrasonic device 1 that can suppress unwanted ultrasonic waves and can be made thin.

[0083] According to the ultrasonic device 1 of the present embodiment, ultrasonic waves emitted from the ultrasonic elements 10 can be made to be efficiently incident on the corresponding slits 202 by arranging the slits 202 at distances equal to the arrangement distance between the ultrasonic elements 10 arranged in the shape of an array. Therefore, since it is possible to efficiently arrange the slits 202, it is possible to suppress unwanted ultrasonic waves returning to the ultrasonic element 10 from the backing unit 20. As a result, the backing unit 20 can be made thin.

[0084] According to the ultrasonic device 1 of the present embodiment, since the backing unit 20 is coated with the coating material 205, it is possible to prevent the generation of an air layer between the ultrasonic element 10 and the backing unit 20. In a case where a silicone resin is used as the coating material 205, it is possible to approximately match the acoustic impedance of the coating material 205 with the acoustic impedance of the ultrasonic element 10. Therefore, ultrasonic waves emitted from the ultrasonic element 10 can be made to be efficiently incident on the backing unit 20 while suppressing reflection on the boundary surface of the backing unit 20. In addition, since the generation of an air layer inside the slit 202 is prevented, it is possible to efficiently transmit reflected ultrasonic waves. Accordingly, it is possible to suppress unwanted ultrasonic waves returning to the ultrasonic element 10 from the backing unit 20.

[0085] Since the ultrasonic probe 100 of the present embodiment is configured such that the thin ultrasonic device 1 is housed in the housing member 80, it is possible to make the ultrasonic probe 100 thin. In addition, since the ultrasonic device 1 for suppressing unwanted ultrasonic waves is housed in the ultrasonic probe 100, it is possible to prevent unwanted ultrasonic waves from riding as noise on the ultrasonic waves emitted toward the subject from the ultrasonic device 1. Therefore, it is possible to improve the quality of the ultrasonic probe 100.

[0086] Since the ultrasonic imaging apparatus 110 of the present embodiment includes the thin ultrasonic probe 100, the processing device 101, and the display device 102, it is possible to improve the convenience of the ultrasonic imaging apparatus 110.

[0087] In addition, since the ultrasonic imaging apparatus 110 of the present embodiment includes the ultrasonic probe 100 capable of suppressing unwanted ultrasonic waves riding as noise, it is possible to suppress the occurrence and

display of artifacts as noise during B-mode imaging. Therefore, the ultrasonic imaging apparatus 110 can generate a clear B-mode image. Thus, it is possible to improve the quality of the ultrasonic imaging apparatus 110. In addition, since the operator uses the ultrasonic imaging apparatus 110 capable of suppressing artifacts in an examination or the like, it is possible to reduce false findings. Accordingly, it is possible to make an accurate diagnosis.

Second Embodiment

[0088] FIG. 9 is a sectional view showing the configuration of an ultrasonic device 1A according to a second embodiment. The configuration and operation of the ultrasonic device 1A of the present embodiment will be described with reference to FIG. 9.

[0089] In the ultrasonic device 1A of the present embodiment, the configuration of a backing unit 20A is different from that in the ultrasonic device 1 of the first embodiment. The other configuration is the same as the ultrasonic device 1 of the first embodiment. The same components as in the first embodiment are denoted by the same reference numerals.

[0090] The backing unit 20A of the present embodiment is formed by superimposing two backing units 20 of the first embodiment in the thickness direction. In the backing unit 20A, the two backing units 20 are superimposed such that the slits 202 of the backing members 201 are symmetrical with respect to the overlapping surface.

[0091] In the assembly of the backing unit 20A, one of the two backing units 20 is turned upside down first. Then, the one backing unit 20 that is turned upside down is aligned on the bottom surface of the other backing unit 20 that is not turned upside down, and the one backing unit 20 and the other backing unit 20 are bonded to each other with an adhesive layer 60 interposed therebetween, thereby completing the backing unit 20A. In the present embodiment, a so-called double-sided tape is used as the adhesive layer 60.

[0092] Accordingly, the slit 202 of the first (previous-stage) backing unit 20 and the slit 202 of the next (subsequent-stage) backing unit 20 are disposed so as to be plane-symmetrical. Thus, in the backing unit 20A, the previous-stage slit 202 and the subsequent-stage slit 202 are connected to each other with the adhesive layer 60 or the coating material 205 interposed therebetween.

[0093] Next, the operation of the backing unit 20A with respect to ultrasonic waves will be described. In FIG. 9, the traveling direction of the ultrasonic wave is schematically shown by arrows. In the operation of the backing unit 20A with respect to ultrasonic waves, the operation in the previous-stage backing unit 20 is the same as that described in the first embodiment. Accordingly, the following explanation will be given from a point in time at which ultrasonic waves are emitted from the previous-stage backing unit 20.

[0094] As shown by arrows in FIG. 9, the ultrasonic wave emitted from the previous-stage backing unit 20 is transmitted through the adhesive layer 60 to be incident on the subsequent-stage backing unit 20. Then, the ultrasonic wave is transmitted through the coating material 205 of the subsequent-stage backing unit 20 to efficiently travel to the inside of the subsequent-stage slit 202 connected to the slit 202 of the previous-stage backing unit 20. Then, the ultrasonic wave travels while being repeatedly reflected as described above due to the inner walls of the inclined slits 202.

[0095] Thus, in the backing unit 20A of the present embodiment, the ultrasonic wave travels through the two backing units 20 while being repeatedly reflected by the slits 202. Accordingly, the travel path (travel distance) of the ultrasonic wave is longer than that in the case of one backing unit 20. For this reason, since the ultrasonic wave is further diffused or scattered, the ultrasonic wave is further attenuated compared with the first embodiment.

[0096] In addition, in a case where a portion above the backing unit 20A is an air layer and the ultrasonic wave reaching the end surface of the backing unit 20A is totally reflected finally, the ultrasonic wave travels through the slit 202 again while being repeatedly reflected in a path in an opposite direction to that described above. Due to such an operation, the ultrasonic wave returning to the ultrasonic element 10 is further attenuated compared with the first embodiment.

[0097] According to the ultrasonic device 1A of the embodiment described above, not only can the same effect as in the ultrasonic device 1 of the first embodiment be obtained, but also the following effects are obtained.

[0098] According to the ultrasonic device 1A of the present embodiment, the backing unit 20A is formed by superimposing the two backing units 20 in the thickness direction. The two backing units 20 are superimposed such that the slits 202 thereof are plane-symmetrical. In this manner, the length of the travel path of the ultrasonic wave by the backing unit 20A can be increased. As a result, it is possible to further attenuate the ultrasonic wave. In addition, it is possible to further attenuate the ultrasonic wave returning to the ultrasonic element 10. In addition, it is possible to improve the rigidity of the backing unit 20A by superimposing the two backing units 20, even though the rigidity of the backing unit 20A depends on the thickness of the backing unit 20A allowed in the ultrasonic device 1A.

Third Embodiment

[0099] FIG. 10 is a sectional view showing the configuration of an ultrasonic device 1B according to a third embodiment. The configuration and operation of the ultrasonic device 1B of the present embodiment will be described with reference to FIG. 10.

[0100] In the ultrasonic device 1B of the present embodiment, the configuration of a backing unit 20B is different from that in the ultrasonic device 1 of the first embodiment. The other configuration is the same as the ultrasonic device 1 of the first embodiment. The same components as in the first embodiment are denoted by the same reference numerals.

[0101] The backing unit 20B of the present embodiment has a configuration in which two backing units are superimposed, as in the second embodiment. However, the superposition direction is different from that in the second embodiment. The backing unit 20B of the present embodiment is formed by superimposing a new backing unit 21 on the backing unit 20 in the first embodiment. Similar to the backing unit 20, the backing unit 21 of the present embodiment is formed using a backing member 211 having slits 212 that are inclined in the thickness direction. The entire backing member 211 is coated with the same coating material 205 as in the first embodiment.

[0102] In a case where the backing unit 21 is superimposed on the bottom surface of the backing unit 20, the slits 212 of the backing unit 21 (backing member 211) are

disposed at positions on the extensions of the slits **202** of the backing unit **20** (backing member **201**). Thus, the slit **202** of the backing unit **20** and the slit **212** of the backing unit **21** are connected to each other with the adhesive layer **60** or the coating material **205** interposed therebetween. In addition, the position and the inclination angle of the slit **212** of the backing unit **21** are adjusted so that the slit **212** can be connected to the slit **202**.

[0103] Next, the operation of the backing unit **20B** with respect to ultrasonic waves will be described. In FIG. **10**, the traveling direction of the ultrasonic wave is schematically shown by arrows. In the operation of the backing unit **20B** with respect to ultrasonic waves, the operation in the backing unit **20** is the same as that described in the first embodiment. Accordingly, the following explanation will be given from a point in time at which ultrasonic waves are emitted from the backing unit **20**.

[0104] As shown by arrows in FIG. **10**, the ultrasonic wave emitted from the backing unit **20** is transmitted through the adhesive layer **60** to be incident on the backing unit **21**. Then, the ultrasonic wave is transmitted through the coating material **205** of the backing unit **21** to efficiently travel to the inside of the slit **212** connected to the slit **202** of the backing unit **20**. Then, the ultrasonic wave travels while being repeatedly reflected as described above due to the inner walls of the inclined slits **212**.

[0105] Thus, in the backing unit **20B** of the present embodiment, the ultrasonic wave travels through the two backing units **20** and **21** while being repeatedly reflected. Accordingly, the travel path (travel distance) of the ultrasonic wave is longer than that in the case of one backing unit **20**. For this reason, since the ultrasonic wave is further diffused or scattered, the ultrasonic wave is further attenuated compared with the first embodiment.

[0106] In addition, in a case where a portion above the backing unit **20B** is an air layer and the ultrasonic wave reaching the end surface of the backing unit **20B** is totally reflected finally, the ultrasonic wave travels through the slits **212** and **202** again while being reflected in a path in an opposite direction to that described above. Due to such an operation, the ultrasonic wave returning to the ultrasonic element **10** is further attenuated compared with the first embodiment.

[0107] According to the ultrasonic device **1B** of the embodiment described above, it is possible to obtain the same effect as in the ultrasonic devices **1** and **1A** of the first and second embodiments.

[0108] The invention is not limited to the embodiments described above, and can be implemented by adding various modifications, improvements, or the like within a range not departing from the spirit of the invention. Modification examples will be described below.

[0109] In the ultrasonic device **1** of the first embodiment, the backing unit **20** is formed on the surface (second surface) of the ultrasonic element **10** opposite to the element forming surface. However, without being limited thereto, the backing unit **20** may be formed on the element forming surface. In this case, the element forming surface becomes a second surface. This is the same in the second and third embodiments.

[0110] In the ultrasonic device **1** of the first embodiment, the slit **202** of the backing unit **20** (backing member **201**) is formed so as to extend in the slice direction **D1**. However, without being limited thereto, the slit **202** may be formed so

as to extend in the scan direction **D2**. This is the same in the second and third embodiments.

[0111] In the ultrasonic device **1** of the first embodiment, the slit **202** of the backing unit **20** (backing member **201**) is formed so as to extend in the slice direction **D1**. In other words, the slit **202** is formed corresponding to one column of ultrasonic elements **10** formed in the slice direction **D1**. However, without being limited thereto, one slit **202** may be formed corresponding to one ultrasonic element **10**. In addition, one slit **202** may be formed corresponding to a plurality of ultrasonic elements **10** including the adjacent ultrasonic elements **10**. This is the same in the second and third embodiments.

[0112] In the ultrasonic device **1** of the first embodiment, the slits **202** of the backing unit **20** (backing member **201**) are formed in the slice direction **D1** at distances (pitches) equal to the arrangement distance between the ultrasonic elements **10**. In other words, one slit **202** is formed in the slice direction **D1** corresponding to one column of ultrasonic elements **10**. However, without being limited thereto, a plurality of slits **202** may be formed corresponding to one column of ultrasonic elements **10**. This also means that a plurality of slits **202** may be formed corresponding to one ultrasonic element **10**. This is the same in the second and third embodiments.

[0113] In the ultrasonic device **1** of the first embodiment, the inclined slit **202** is provided corresponding to the ultrasonic element **10** of the ultrasonic element array **10A**. In the ultrasonic element array **10A**, however, in a case where the ultrasonic element **10** located on the outer peripheral side is a dummy ultrasonic element, no slit **202** may be provided for the dummy ultrasonic element **10**. This is the same in the second and third embodiments.

[0114] The ultrasonic device **1A** of the second embodiment is formed by superimposing and bonding the two backing units **20** to each other. However, without being limited to this configuration, the ultrasonic device **1A** may be formed by superimposing the two backing members **201** such that the slits **202** are plane-symmetrical first and then coating the two backing members **201** together using the coating material **205**. This is the same also in the ultrasonic device **1B** of the third embodiment. That is, the ultrasonic device **1B** may be formed by superimposing the two backing members **201** and **211** such that the slits **212** are connected to the extensions of the slits **202** first and then coating the two backing members **201** and **211** together using the coating material **205**.

[0115] The ultrasonic devices **1A** and **1B** of the second and third embodiments are formed by superimposing and bonding two backing units to each other. However, without being limited to this configuration, the ultrasonic devices **1A** and **1B** may be formed by superimposing three or more backing units. However, in the case of superimposing backing units, it is necessary to superimpose the backing units in a state in which inclined slits are connected to each other, so that the ultrasonic wave reflected from the inside of each slit can travel through the next slit.

[0116] The ultrasonic device **1** of the first embodiment is configured to include the thin-film ultrasonic element **10** (ultrasonic element array **10A**). However, without being limited thereto, the invention can also be applied to a bulk type ultrasonic device. In this case, it is possible to make a backing unit thin by using a backing unit having a slit that is inclined in the thickness direction.

What is claimed is:

1. An ultrasonic device that transmits and receives ultrasonic waves, comprising:

ultrasonic elements including first and second surfaces from which the ultrasonic waves are emitted; and a backing unit that supports the second surfaces of the ultrasonic elements and attenuates the ultrasonic waves emitted to the second surface side, wherein the backing unit has slits inclined in a thickness direction.

2. The ultrasonic device according to claim 1, wherein the ultrasonic elements are arranged in a shape of an array.

3. The ultrasonic device according to claim 2, wherein the slits are arranged at distances equal to an arrangement distance between the ultrasonic elements arranged in the shape of an array.

4. The ultrasonic device according to claim 1, wherein the backing unit is superimposed in the thickness direction.

5. The ultrasonic device according to claim 1, wherein the backing unit is coated with a coating material.

6. An ultrasonic probe comprising: the ultrasonic device according to claim 1; and a housing member that houses the ultrasonic device such that a part of the ultrasonic device is exposed.

7. An ultrasonic probe comprising: the ultrasonic device according to claim 2; and a housing member that houses the ultrasonic device such that a part of the ultrasonic device is exposed.

8. An ultrasonic probe comprising: the ultrasonic device according to claim 3; and a housing member that houses the ultrasonic device such that a part of the ultrasonic device is exposed.

9. An ultrasonic probe comprising: the ultrasonic device according to claim 4; and a housing member that houses the ultrasonic device such that a part of the ultrasonic device is exposed.

10. An ultrasonic probe comprising: the ultrasonic device according to claim 5; and a housing member that houses the ultrasonic device such that a part of the ultrasonic device is exposed.

11. An electronic apparatus comprising: the ultrasonic probe according to claim 6; and a processing device that controls the ultrasonic probe and processes an input signal from the ultrasonic probe.

12. An electronic apparatus comprising: the ultrasonic probe according to claim 7; and a processing device that controls the ultrasonic probe and processes an input signal from the ultrasonic probe.

13. An electronic apparatus comprising:

the ultrasonic probe according to claim 8; and a processing device that controls the ultrasonic probe and processes an input signal from the ultrasonic probe.

14. An electronic apparatus comprising: the ultrasonic probe according to claim 9; and a processing device that controls the ultrasonic probe and processes an input signal from the ultrasonic probe.

15. An electronic apparatus comprising: the ultrasonic probe according to claim 10; and a processing device that controls the ultrasonic probe and processes an input signal from the ultrasonic probe.

16. An ultrasonic imaging apparatus comprising: the ultrasonic probe according to claim 6; a processing device that controls the ultrasonic probe and generates an image by processing an input signal from the ultrasonic probe; and a display device that displays the image generated by the processing device.

17. An ultrasonic imaging apparatus comprising: the ultrasonic probe according to claim 7; a processing device that controls the ultrasonic probe and generates an image by processing an input signal from the ultrasonic probe; and a display device that displays the image generated by the processing device.

18. An ultrasonic imaging apparatus comprising: the ultrasonic probe according to claim 8; a processing device that controls the ultrasonic probe and generates an image by processing an input signal from the ultrasonic probe; and a display device that displays the image generated by the processing device.

19. An ultrasonic imaging apparatus comprising: the ultrasonic probe according to claim 9; a processing device that controls the ultrasonic probe and generates an image by processing an input signal from the ultrasonic probe; and a display device that displays the image generated by the processing device.

20. An ultrasonic imaging apparatus comprising: the ultrasonic probe according to claim 10; a processing device that controls the ultrasonic probe and generates an image by processing an input signal from the ultrasonic probe; and a display device that displays the image generated by the processing device.

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摘要(译)

发送和接收超声波的超声波装置包括：超声波元件，包括发射超声波的第一和第二表面；支撑单元，支撑超声波元件的第二表面，并衰减发射到第二表面侧的超声波。背衬单元具有沿厚度方向倾斜的狭缝。超声波元件以阵列的形状布置，并且狭缝布置的距离等于以阵列形状布置的超声波元件之间的布置距离。

