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Ooishi et al.

(54) **TWO-DIMENSIONAL-ARRAY ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS**

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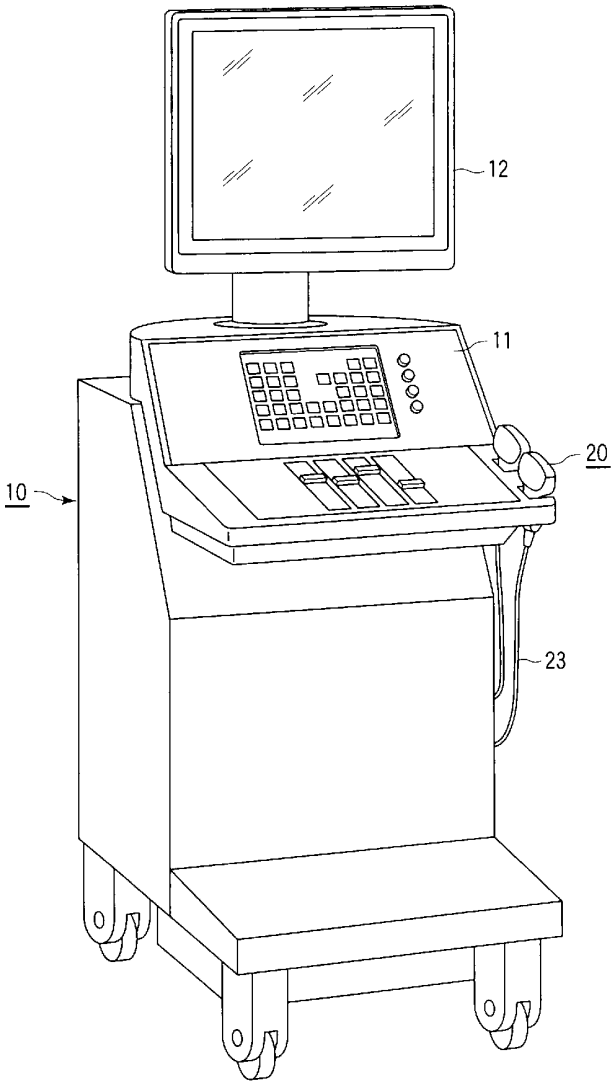
(52) **U.S. Cl.** **600/459**

(57) **ABSTRACT**

According to one embodiment, an ultrasonic probe comprises piezoelectric elements arranged in the form of a two-dimensional array, a processing IC configured to process signal information obtained from the piezoelectric elements, and a flexible wiring substrate disposed between the piezoelectric elements and the processing IC, with the piezoelectric elements mounted on a front surface, and the processing IC mounted on a rear surface.



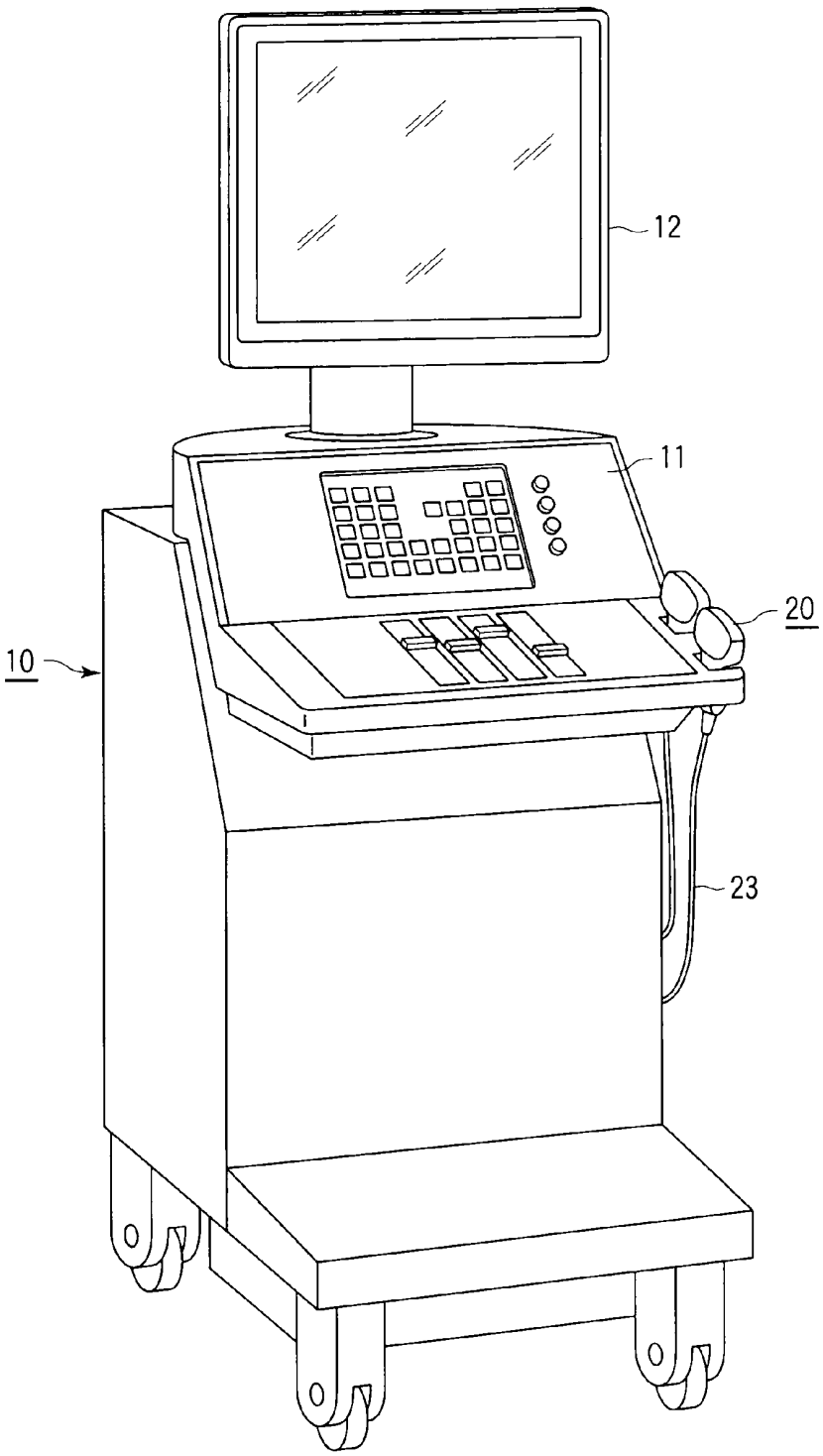


FIG. 1

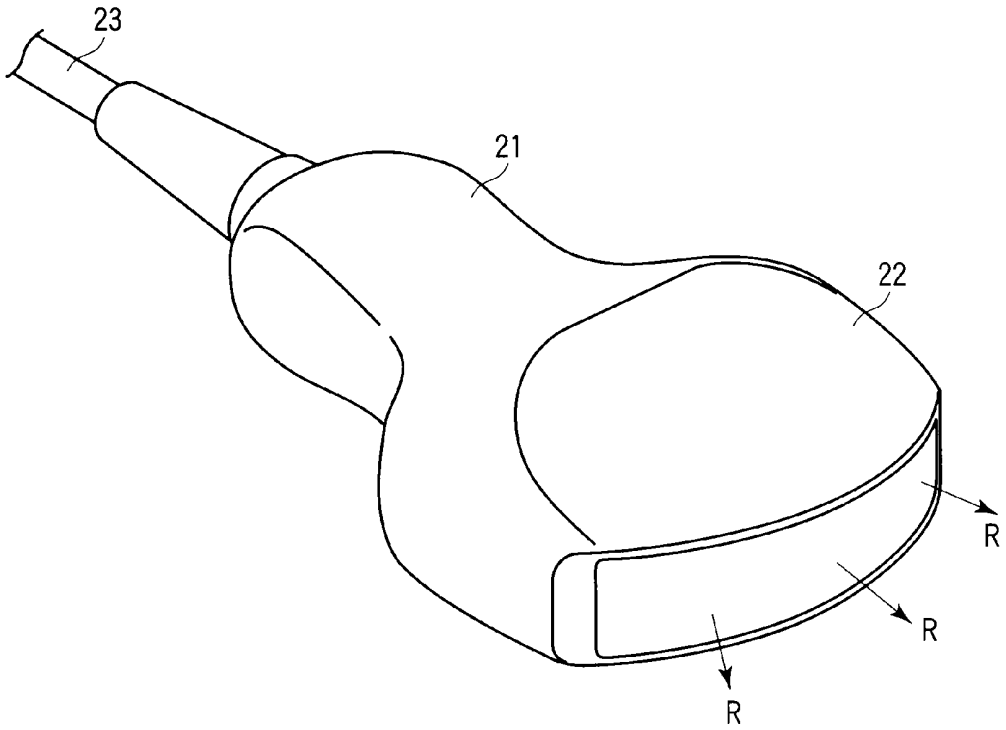


FIG. 2

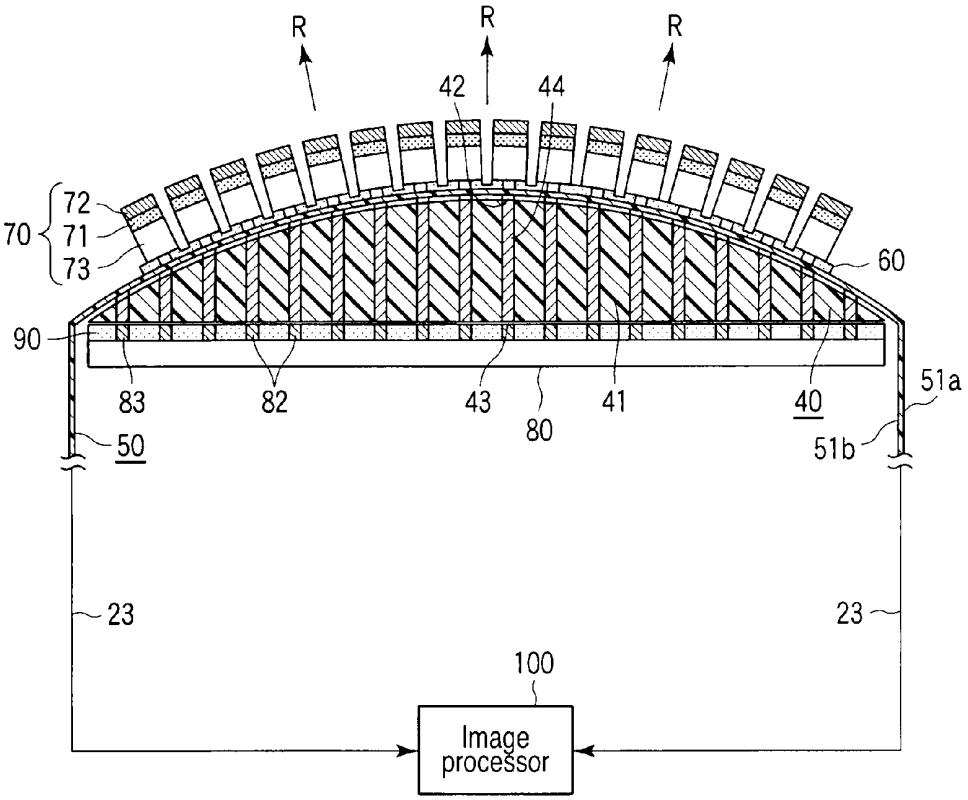

R
R
R
42
44
72
71
73
70
60
90
83
82
43
80
41
40
51a
50
51b
23
23
100
Image processor

FIG. 3

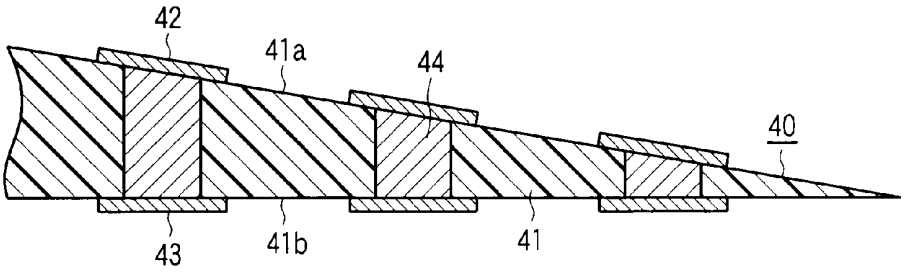

42
41a
44
40
43
41b
41

FIG. 4

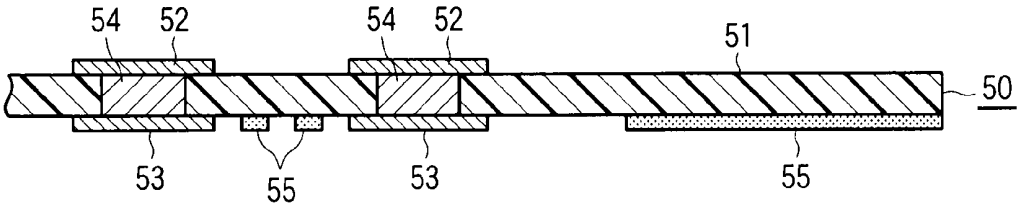


FIG. 5

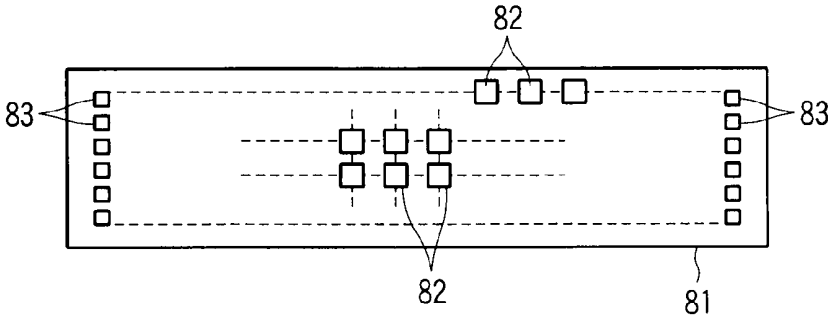


FIG. 6

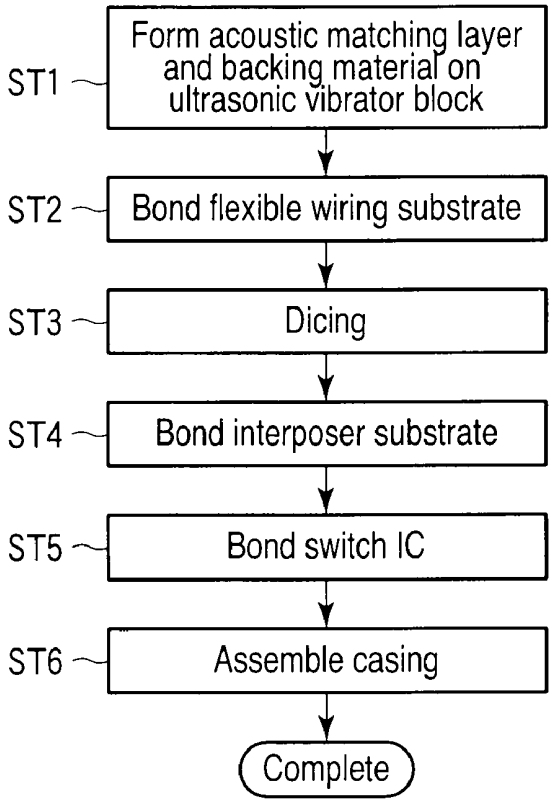

ST1
Form acoustic matching layer and backing material on ultrasonic vibrator block
ST2
Bond flexible wiring substrate
ST3
Dicing
ST4
Bond interposer substrate
ST5
Bond switch IC
ST6
Assemble casing
Complete

FIG. 7

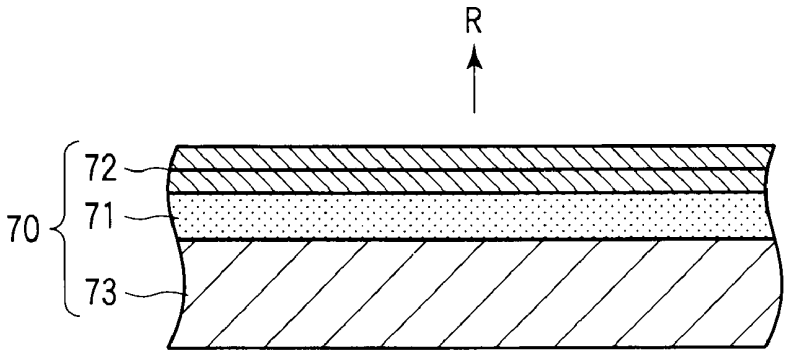

R
72
71
70
73

FIG. 8

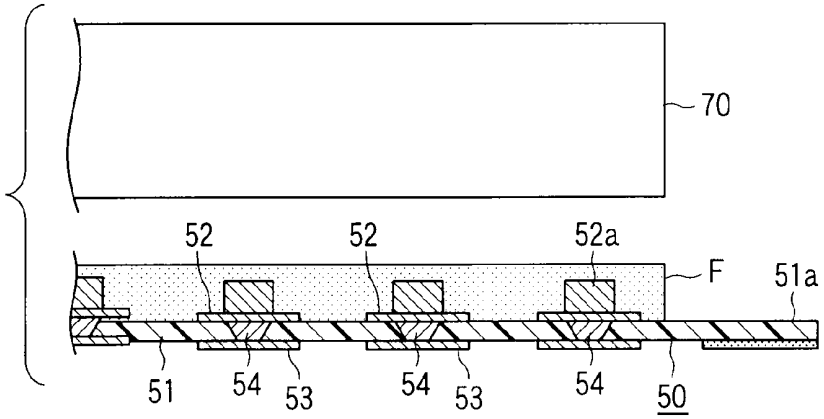


FIG. 9A

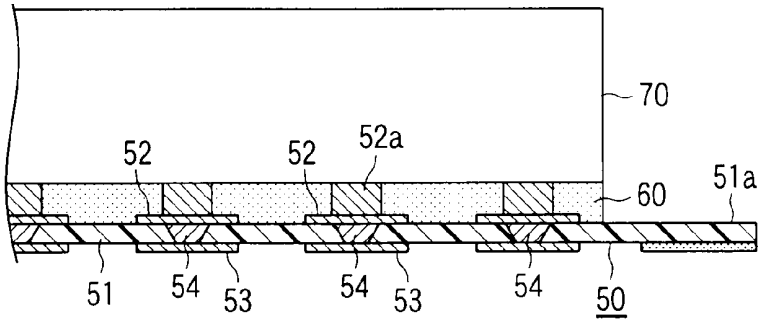


FIG. 9B

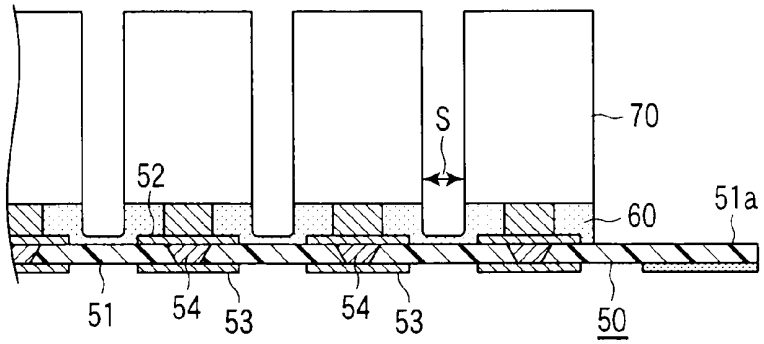


FIG. 9C

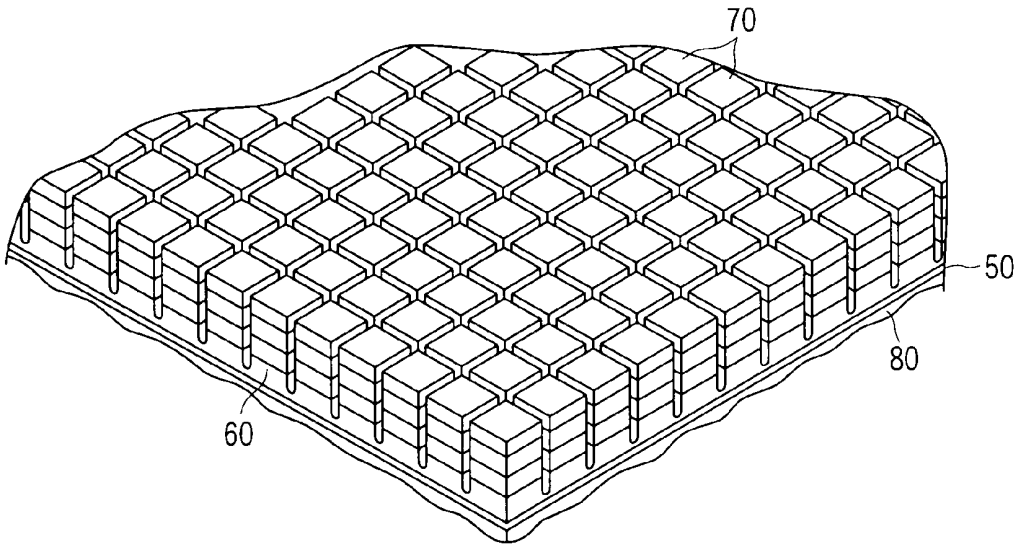


FIG. 10

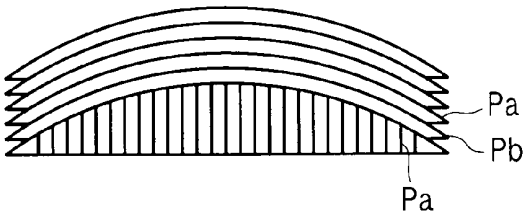


FIG. 11A

FIG. 11B

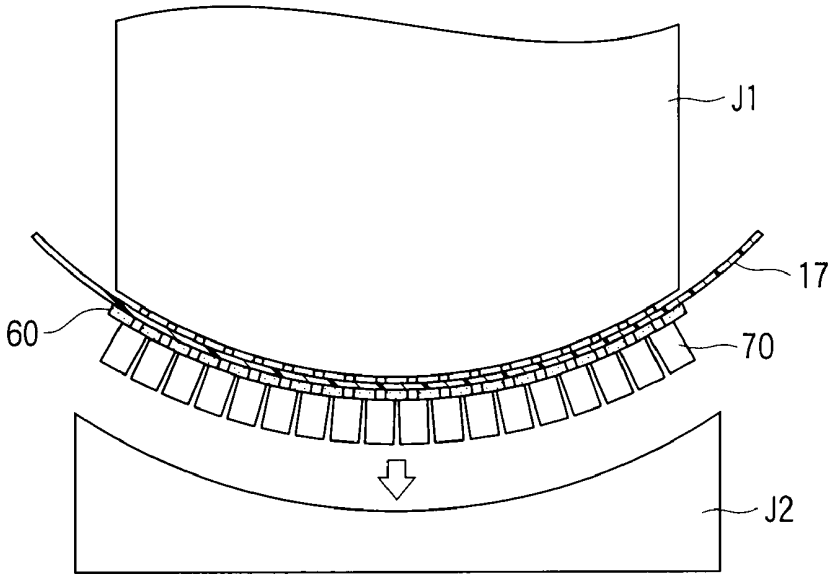


FIG. 12A

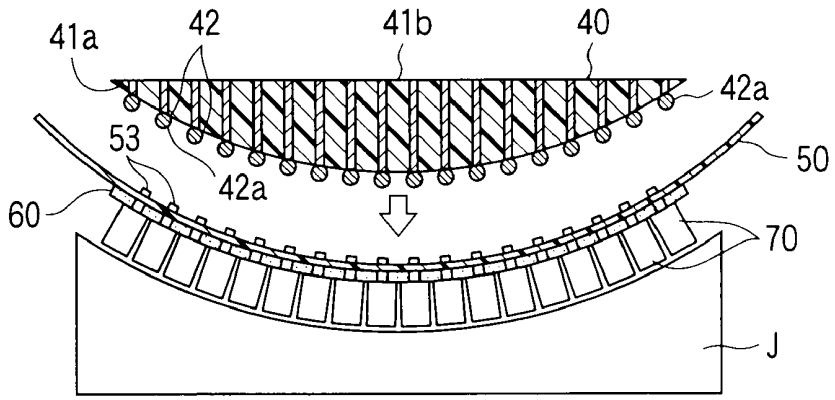


FIG. 12B

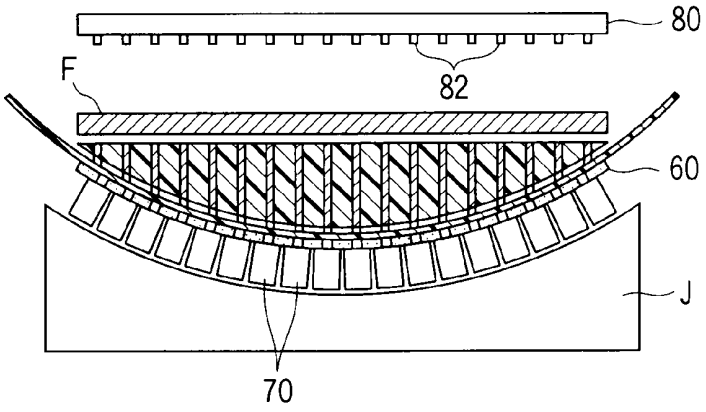


FIG. 12C

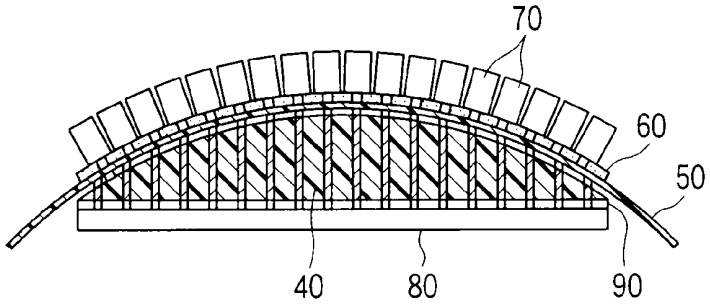


FIG. 12D

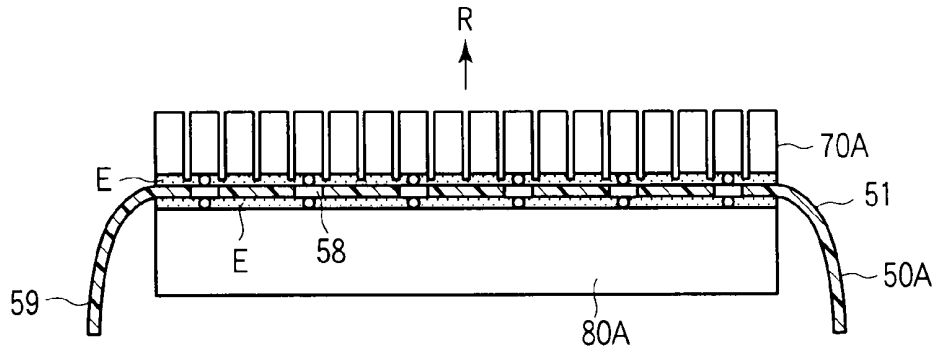


FIG. 13

TWO-DIMENSIONAL-ARRAY ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2010-068683, filed Mar. 24, 2010; the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to a two-dimensional-array ultrasonic probe that outputs ultrasonic waves by using piezoelectric elements arranged in the form of a two-dimensional array and receives reflected ultrasonic waves, and an ultrasonic diagnostic apparatus with such a two-dimensional-array ultrasonic probe incorporated therein.

BACKGROUND

[0003] A two-dimensional-array ultrasonic probe is used in an ultrasonic diagnostic apparatus used for a diagnosis of an echo image. The two-dimensional-array ultrasonic probe is an apparatus with piezoelectric elements arranged in a head in the form of a two-dimensional array, so as to output ultrasonic waves from the piezoelectric elements and receive reflected ultrasonic waves, wherein a detected signal is transmitted to an inspection device body, etc., via a cable, which is then subjected to image processing and is used for a diagnosis, etc.

[0004] The aforementioned two-dimensional-array ultrasonic probe involves the following problem. Namely, in recent years, a real time diagnosis by a three-dimensional moving image is realized, and in order to obtain a clear image, a design of increasing the number of channels of the piezoelectric elements mounted on a head has been attempted. With such a design, the number of connection wires for connecting to the inspection device body is increased, resulting in a thick cable of these connection wires. In a case of the thick wire, the head of the two-dimensional-array ultrasonic probe is hardly moved, thus unfavorably disturbing the diagnosis.

[0005] Therefore, in order to achieve a real time diagnosis by the three-dimensional moving image, and in order to obtain a clear image, it is desired to provide a two-dimensional-array ultrasonic probe easy to be handled with no necessity of making the cable thick even if the number of channels is increased, and an ultrasonic diagnostic apparatus with such a two-dimensional-array ultrasonic probe incorporated therein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a perspective view showing an ultrasonic diagnostic apparatus with an ultrasonic probe incorporated therein according to a first embodiment;

[0007] FIG. **2** is a perspective view showing the aforementioned ultrasonic probe;

[0008] FIG. **3** is an explanatory view showing a detector incorporated in the aforementioned ultrasonic probe;

[0009] FIG. **4** is a cross-sectional view showing an essential part of an interposer substrate incorporated in the aforementioned detector;

[0010] FIG. **5** is a cross-sectional view showing an essential part of a flexible wiring substrate incorporated in the aforementioned detector;

[0011] FIG. **6** is a plan view showing a switch IC incorporated in the aforementioned detector;

[0012] FIG. **7** is a flowchart showing manufacturing steps of the aforementioned ultrasonic probe;

[0013] FIG. **8** is an explanatory view showing the aforementioned manufacturing steps;

[0014] FIG. **9**A is an explanatory view showing the aforementioned manufacturing steps;

[0015] FIG. **9**B is an explanatory view showing the aforementioned manufacturing steps;

[0016] FIG. **9**C is an explanatory view showing the aforementioned manufacturing steps;

[0017] FIG. **10** is an explanatory view showing the aforementioned manufacturing steps;

[0018] FIG. **11**A is an explanatory view showing the aforementioned manufacturing steps;

[0019] FIG. **11**B is an explanatory view showing the aforementioned manufacturing steps;

[0020] FIG. **12**A is an explanatory view showing the aforementioned manufacturing steps;

[0021] FIG. **12**B is an explanatory view showing the aforementioned manufacturing steps;

[0022] FIG. **12**C is a vertical cross-sectional view showing the aforementioned manufacturing steps;

[0023] FIG. **12**D is a vertical cross-sectional view showing the aforementioned manufacturing steps; and

[0024] FIG. **13** is an explanatory view showing the detector incorporated in the ultrasonic probe according to a second embodiment.

DETAILED DESCRIPTION

[0025] In general, according to one embodiment, a two-dimensional-array ultrasonic probe comprises: piezoelectric elements arranged in the form of a two-dimensional array; a processing IC for processing signal information obtained from the piezoelectric elements; and a flexible wiring substrate disposed between the piezoelectric elements and the processing IC, with the piezoelectric elements mounted on a front surface, and the processing IC mounted on a rear surface.

[0026] FIG. **1** is a perspective view showing an ultrasonic diagnostic apparatus **10** according to a first embodiment; FIG. **2** is a perspective view showing an ultrasonic probe **20** incorporated in the ultrasonic diagnostic apparatus **10**; and FIG. **3** is a cross-sectional view showing a structure of a detector **30** incorporated in the ultrasonic probe **20**. Note that R in the figure shows an irradiating direction of ultrasonic waves.

[0027] As shown in FIG. **1**, the ultrasonic diagnostic apparatus **10** comprises: a diagnostic apparatus body **11**; an image monitor **12** attached to the diagnostic apparatus body **11**; and an ultrasonic probe (convex two-dimensional-array ultrasonic probe) **20** attached via a cable **13** from the diagnostic apparatus body **11**.

[0028] An image processor **100** is provided inside of the diagnostic apparatus body **11**, for forming an image by processing a signal sent from the ultrasonic probe **20**. Further, the image monitor **12** has a function of displaying the image formed by the image processor **100**.

[0029] As shown in FIG. **2**, the ultrasonic probe **20** comprises: a hand portion **21** grasped by an operator; a head **22** in which the detector **30** is accommodated; and a cable **23** for

transmitting and receiving signals to/from the diagnostic apparatus body **11**. Note that the head **22** has a convex surface in the irradiating direction of the ultrasonic waves (shown by an arrow R in FIG. **2**).

[0030] As shown in FIG. **3**, the detector **30** comprises: an interposer substrate (relay substrate) **40** formed into a convex shape (convex type); a flexible wiring substrate **50** disposed with its rear surface side facing the convex side of the interposer substrate **40**; two-dimensional-array piezoelectric elements **70** mounted on the front surface side of the flexible wiring substrate **50** via an adhesive layer **60**; and a switch IC (processing IC) **80** mounted on a flat-plate side of the interposer substrate **40** via an adhesive layer **90**.

[0031] FIG. **4** is a cross-sectional view showing an essential part of the interposer substrate **40**. As shown in FIG. **4**, the interposer substrate **40** comprises: a base material **41** including a resin material; first electrodes **42** provided on a front surface **41***a* side of the base material **41**; second electrodes **43** provided on a rear surface **41***b* side; and through electrodes **44** passing through the base material **41** so as to connect the first electrodes **42** and the second electrodes **43**. The surface **41***a* of the base material **41** is formed into a convex shape, and the rear surface **41***b* is formed into a flat-surface shape.

[0032] The first electrodes **42** are connected to second electrodes **53** of the flexible wiring substrate **50**, for taking out electrical wires via the second electrodes **53**. The second electrodes **43** are provided on an opposite surface to the first electrodes **42**, and are electrically connected to the switch IC **80**.

[0033] FIG. **5** is a cross-sectional view showing an essential part of the flexible wiring substrate **50**. The flexible wiring substrate **50** comprises: a base material **51** including a resin material such as polyimide having flexibility; first electrodes **52** provided on a front surface side of the base material **51**; second electrodes **53** provided on a rear surface side; through electrodes **54** passing through the base material **51** so as to connect the first electrodes **52** and the second electrodes **53**; and a wiring part **55** such as a copper foil.

[0034] The first electrodes **52** are connected to the piezoelectric elements **70**, and take out the electrical wires from lower side electrodes (not shown) of the piezoelectric elements **70**. The second electrodes **53** are connected to the first electrodes **42** of the interposer substrate **40**. The wiring portion **55** is pulled out to outside of a connection area connected to the piezoelectric elements **70** and the interposer substrate **40**, and is connected to the image processor **100** via the cable **23**.

[0035] An arrangement pitch of the first electrodes **52** is 400 μm for example, and an interval between adjacent first electrodes **52** is 80 μm. The base material is preferably formed as a thin base, from a point that bending property is required. Further, a bump **52***a* with a height of about 40 μm (Cu core, surface treatment: Ni/Au plating) is formed in each of the first electrodes **52**.

[0036] The adhesive layer **60** has not only a function of preventing the piezoelectric elements **70** from being peeled off in a dicing step of the piezoelectric elements **70** as described later, but also a function of sufficiently securing a depth of dicing so that the piezoelectric elements **70** are cut off by a blade up to a middle thereof in a direction of a thickness (namely, they are not completely cut off).

[0037] Two-dimensional-array piezoelectric elements **70** are arranged in the form of a two-dimensional array, and with the appearance of a convex curved surface, wherein a piezoelectric vibrator **71**, an acoustic matching layer **72**, and a backing material **73** are formed by lamination (see FIG. **8**). A dimension of the piezoelectric elements **70** is 60 mm×10 mm for example.

[0038] The piezoelectric vibrator **71** includes an upper side electrode and a lower side electrode (each of them is not shown) attached to piezoelectric ceramics, etc., such as lead zirconate titanate (PZT). The piezoelectric vibrator **71** has a function of generating ultrasonic waves based on a driving signal from a pulser, and converting a reflected wave to an electrical signal, the reflected wave being reflected from an inspection target.

[0039] The acoustic matching layer **72** can perform matching of acoustic impedance between the inspection target and the piezoelectric vibrator **71** by adjusting physical parameters such as sound speed, thickness, and acoustic impedance.

[0040] In order to shorten an ultrasonic wave pulse, the backing material **73** has a function of mechanically supporting the piezoelectric vibrator **71** and putting a brake on the piezoelectric vibrator **71**. Also, in order to favorably maintain acoustic properties, a thickness of the backing material **73** is set to a sufficient thickness (specifically, a thickness capable of sufficiently attenuating the ultrasonic wave in a back face direction) with respect to a wavelength of an ultrasonic wave to be used.

[0041] As shown in FIG. **6**, the switch IC **80** comprises: an IC main body **81**; area electrodes **82** for inputting the electrical signal received from the piezoelectric elements **70**; and external electrodes **83** for outputting the electrical signal that has undergone signal processing. Although electrical signals received from a plurality of piezoelectric vibrators **71** are input into the switch IC **80** respectively, the electrical signals are output after being converted to signals for generating images. Therefore, the number of output signals can be drastically reduced.

[0042] Next, manufacturing steps of such an ultrasonic probe **20** will be described with reference to a flowchart shown in FIG. **7**. First, as shown in FIG. **8**, the upper side electrode and the lower side electrode are attached for applying a voltage to the piezoelectric vibrator **71**, and the acoustic matching layer **72** is formed on the upper side electrode, and the backing material **73** is formed on the lower side electrode (ST**1**).

[0043] Next, as shown in FIG. **9**A, an anisotropic electroconductive film F, being a base material of the adhesive layer **60**, is laminated on a front surface **51***a* side of the flexible wiring substrate **50**. Then, as shown in FIG. **9**B, the piezoelectric body **70** is aligned at a specified position, and is bonded thereto by using a thermo-compression bonding apparatus (not shown) (ST**2**). Next, as shown in FIG. **9**C, the piezoelectric elements **70** bonded to the flexible wiring substrate **50** are temporarily fixed to a cutting base, and dicing is performed thereto at an interval of 400 μm by using a blade of 50 μm (ST**3**). At this time, a cutting depth is set so that the adhesive layer **60** is cut up to about 20 μm, so that the piezoelectric elements **70** are surely cut. Thereafter, the temporarily fixed flexible wiring substrate **50** (the piezoelectric body **70** is bonded thereto) is removed from the cutting base. FIG. **10** is a perspective view showing the piezoelectric elements **70** and the adhesive layer **60** after dicing.

[0044] Meanwhile, the interposer substrate **40** is formed as shown in FIG. **11**A and FIG. **11**B. Namely, as shown in FIG. **11**A, a printed wiring substrate of 36 layers is prepared, wherein 36 sheets of substrates are laminated on each other

with wiring patterns formed thereon so as to correspond to through electrodes. Next, an outer shape is ground, to thereby form the interposer substrate **40** as shown in FIG. **11**B. Thereafter, total surface plating (such as Ni/Au) and patterning (exposure, developing, or cutting) may be applied to the first electrodes **42** and the second electrodes **43**, as a surface treatment.

[0045] Next, as shown in FIG. **12**A, the piezoelectric elements **70** are arranged with the appearance of a convex shape over an irradiation surface of the ultrasonic wave by using a jig J**1** having a convex curved surface and a jig J**2** having a concave curved surface.

[0046] Next, as shown in FIG. **12**B, solders **42***a* are formed in advance on the first electrodes **42** of the interposer substrate **40**, so that the second electrodes **53** of the flexible wiring substrate **50** and the first electrodes **42** of the interposer substrate **40** are connected to each other by soldering (ST**4**).

[0047] Next, as shown in FIG. **12**C and FIG. **12**D, the anisotropic electroconductive film F is laminated on the interposer substrate **40**, then, the switch IC **80** with an Au bump previously formed on the electrode is aligned at a position of the interposer substrate **40**, to thereby connect the interposer substrate **40** and the switch IC **80** by using the thermal compression bonding apparatus N (ST**5**).

[0048] Thereafter, this is incorporated in a casing (ST**6**), and the ultrasonic probe **20** is completed.

[0049] As described above, in the ultrasonic probe **20** according to this embodiment, by using the interposer substrate **40** with one surface formed into the convex curved surface and having through electrodes, the switch IC **80** for processing huge quantities of signal information obtained from the piezoelectric elements can be connected to the vicinity of the piezoelectric elements **70**. Therefore, the real time diagnosis by the three-dimensional moving image is possible, and even when the number of the piezoelectric body is increased to obtain a clear image, the number of signal cable connected to the image processor **100** can be reduced. Accordingly, the thickness of the cable **23** can be made small, thus making it easy to handle the head **22**.

[0050] FIG. **13** is an explanatory view showing a structure of an ultrasonic probe **20**A according to a second embodiment. Note that in FIG. **13**, the same signs and numerals are assigned to the same functional parts as those of FIG. **3**, and detailed explanation thereof is omitted. The ultrasonic probe **20**A comprises a detector **30**A.

[0051] The detector **30**A comprises: two-dimensional-array piezoelectric elements **70**A which are arranged with the appearance of a flat-plate shape; a flexible wiring substrate **50**A with the piezoelectric elements **70**A mounted on a front surface side via an adhesive layer E; and a switch IC **80**A connected to a rear surface side of the flexible wiring substrate **50**A via the adhesive layer E.

[0052] Thus, when the two-dimensional-array piezoelectric elements **70**A are arranged with the appearance of a flat-plate shape, the detector **30**A can be formed, with an interposer substrate omitted. In the detector **30**A with such a structure, signals obtained by the piezoelectric elements **70** can be sent to an image processor **100** via the switch IC **80**A, thus making it possible to reduce the number of signal cables, and possible to make the thickness of the cable **23** small.

[0053] Note that in an example described above, a gold bump and the anisotropic electroconductive film are used as connection materials. However, for example, an electroconductive adhesive agent or solder, etc., may also be used, and further underfill materials may also be properly used. In addition, grooves provided to the piezoelectric elements may also be filled with epoxy resin, etc. Further, the switch IC is given as an example of the processing IC. However, other processing IC such as control IC may also be used.

[0054] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An ultrasonic probe comprising:

piezoelectric elements arranged in the form of a two-dimensional array;

a processing IC configured to process signal information obtained from the piezoelectric elements; and

a flexible wiring substrate disposed between the piezoelectric elements and the processing IC, with the piezoelectric elements mounted on a front surface, and the processing IC mounted on a rear surface.

2. An ultrasonic probe comprising:

piezoelectric elements arranged in the form of a two-dimensional array and with the appearance of a convex curved-surface shape;

a relay substrate including a substrate main body with a front surface formed into a convex curved-surface shape along the piezoelectric elements, and a rear surface formed into a flat-surface shape, a front surface electrode formed on the front surface, a rear surface electrode formed on the rear surface, and a through electrode passing through from the front surface electrode to the rear surface electrode;

a flexible wiring substrate disposed between the piezoelectric elements and the relay substrate, with the piezoelectric elements mounted on a front surface, and electrodes of the relay substrate connected to a rear surface; and

a processing IC mounted on the rear surface electrode of the relay substrate and configured to process signal information obtained from the piezoelectric elements.

3. An ultrasonic diagnostic apparatus comprising:

an ultrasonic probe including piezoelectric elements arranged in the form of a two-dimensional array, a processing IC configured to process signal information obtained from the piezoelectric elements, and a flexible wiring substrate disposed between the piezoelectric elements and the processing IC, with the piezoelectric elements mounted on a front surface, and the processing IC mounted on a rear surface;

an image processor configured to process a signal sent from the processing IC and form an image; and

an image displayer configured to display the image formed by the image processor.

* * * * *

专利名称(译)	二维阵列超声探头和超声诊断仪		
公开(公告)号	US20110237952A1	公开(公告)日	2011-09-29
申请号	US13/051451	申请日	2011-03-18
[标]申请(专利权)人(译)	大石MICHIKO 朝雾悟 宫城TAKESHI 户崎TAKASHI		
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外部链接	Espacenet USPTO		

摘要(译)

根据一个实施例，超声探头包括以二维阵列的形式布置的压电元件，被配置为处理从压电元件获得的信号信息的处理IC，以及设置在压电元件和处理IC之间的柔性布线基板。压电元件安装在前表面上，处理IC安装在后表面上。