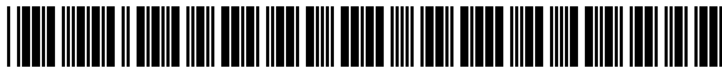

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(54) **ULTRASOUND PROBE AND MANUFACTURING METHOD THEREOF**

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(72) Inventors: **Eunsung LEE**, Hwaseong-si (KR); **Youngil KIM**, Suwon-si (KR); **Jong Keun SONG**, Yongin-si (KR); **Minseog CHOI**, Seoul (KR)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

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(57) **ABSTRACT**

Disclosed herein is an ultrasound probe including a transducer array configured to generate ultrasonic waves, an integrated circuit disposed on a back surface of the transducer array by using an adhesive member, a printed circuit board connected to the integrated circuit and configured to output a signal to the integrated circuit, and a pad bridge disposed on front surfaces of the printed circuit board and the integrated circuit by using the adhesive member and configured to electrically connect the printed circuit board with the integrated circuit. An area of a region of the ultrasound probe contacting the human body may be reduced without reducing the size of the transducer array, and the integrated circuit and the printed circuit board may be integrally connected by using the adhesive member.

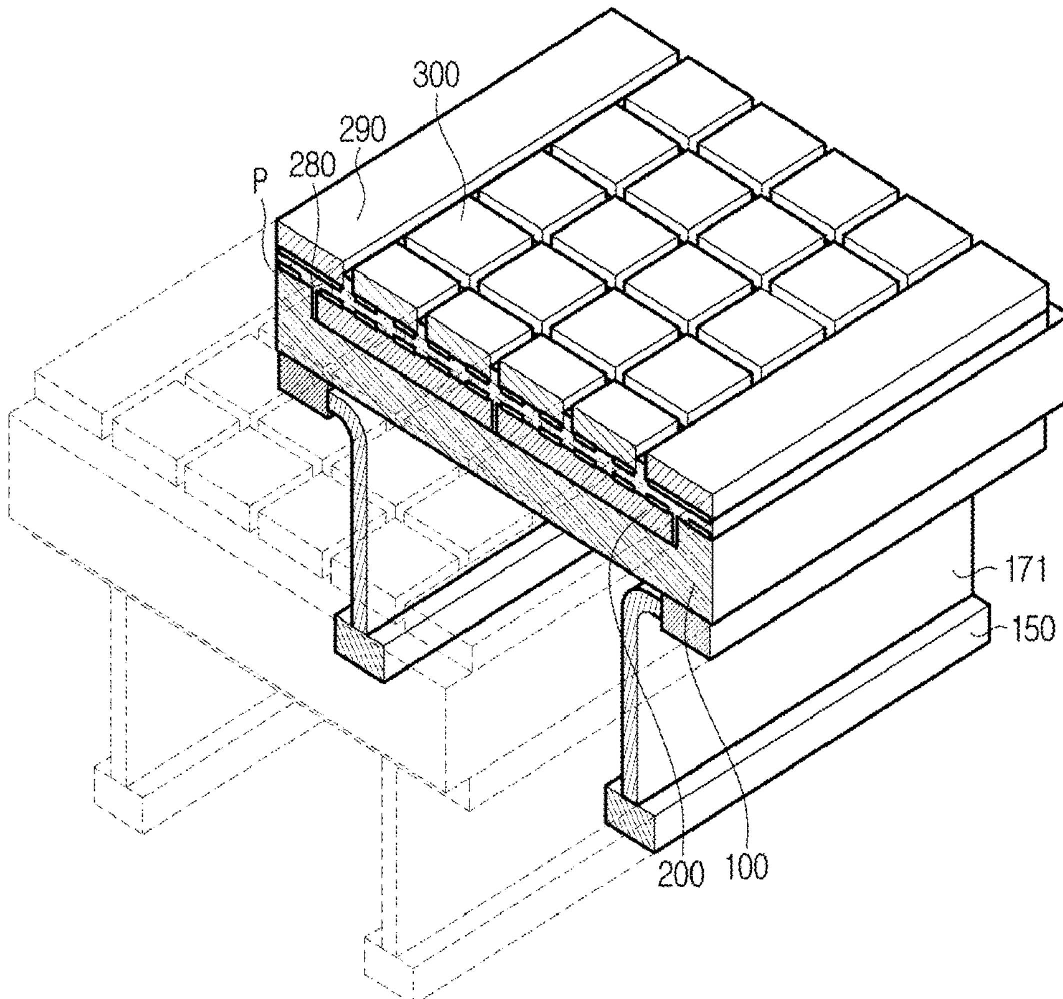


FIG. 1

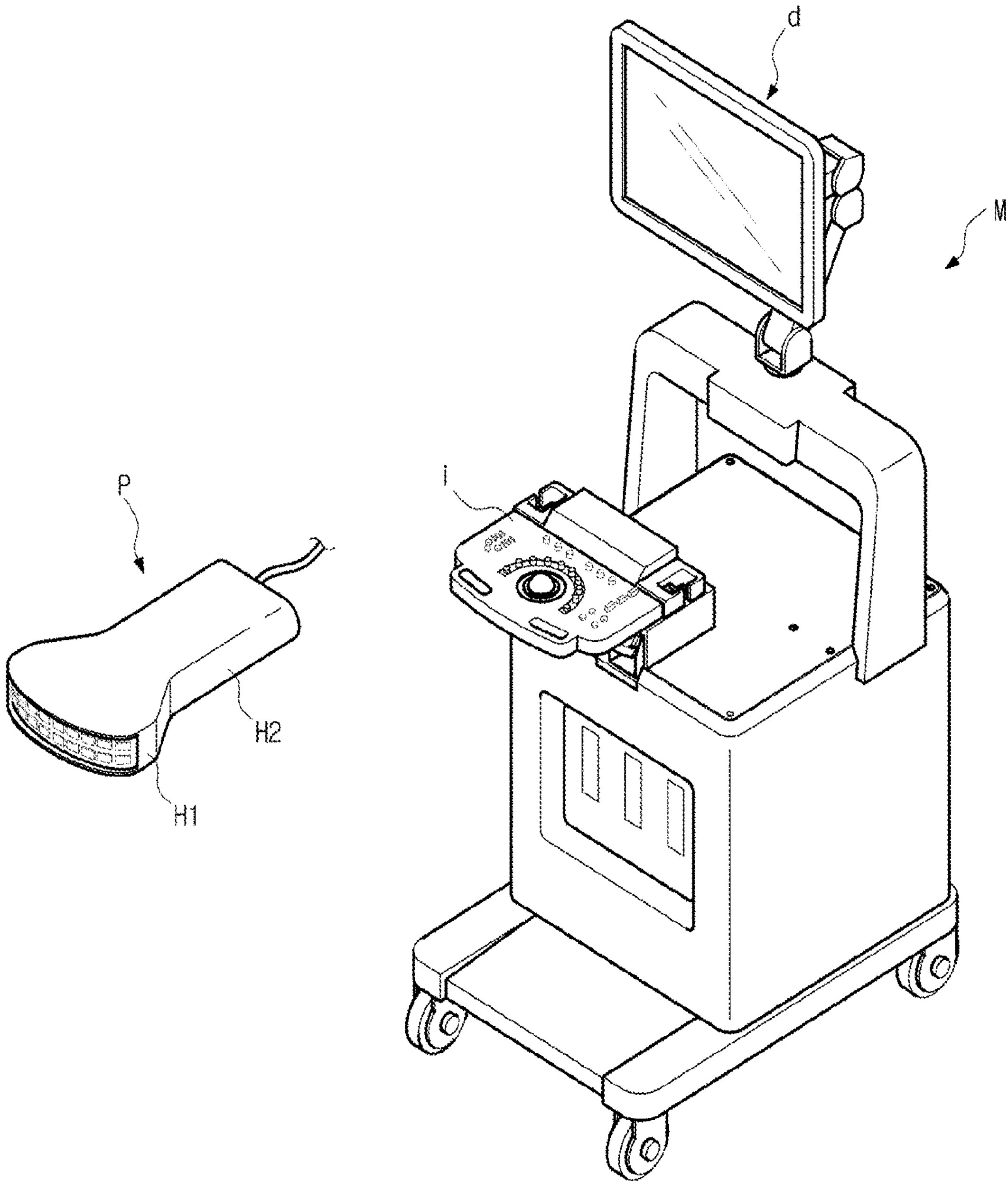


FIG. 2

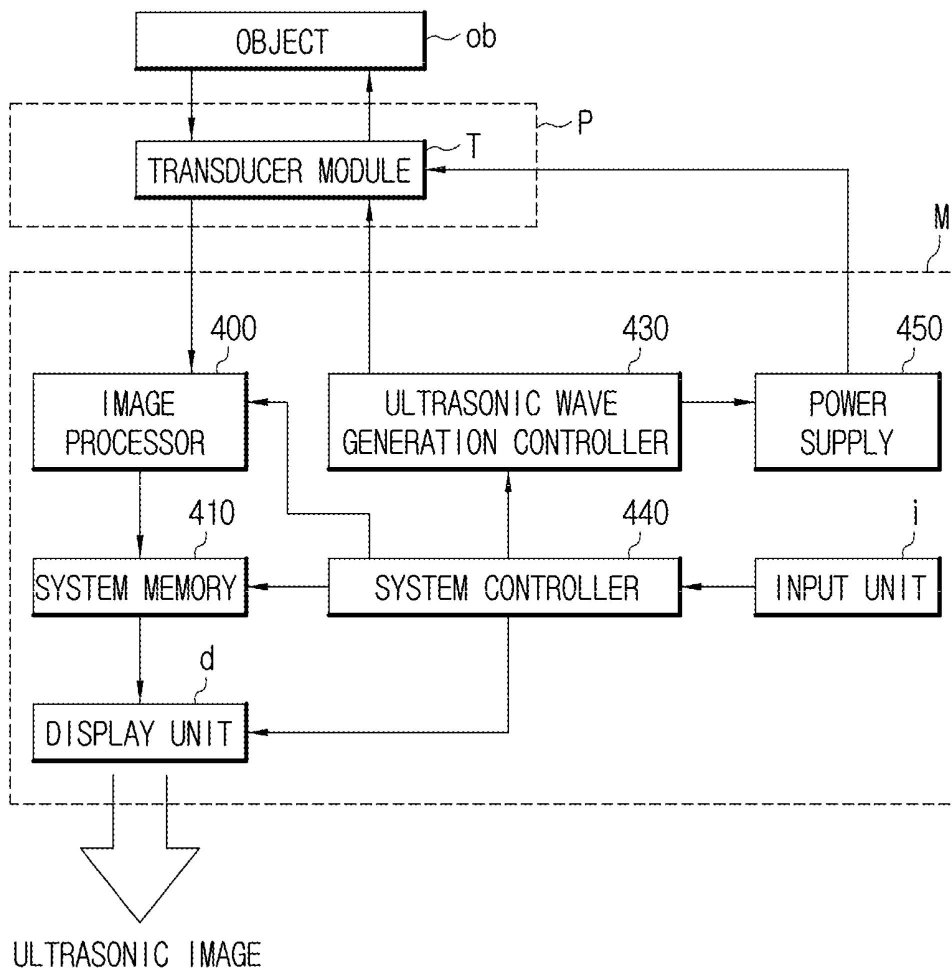


FIG. 3

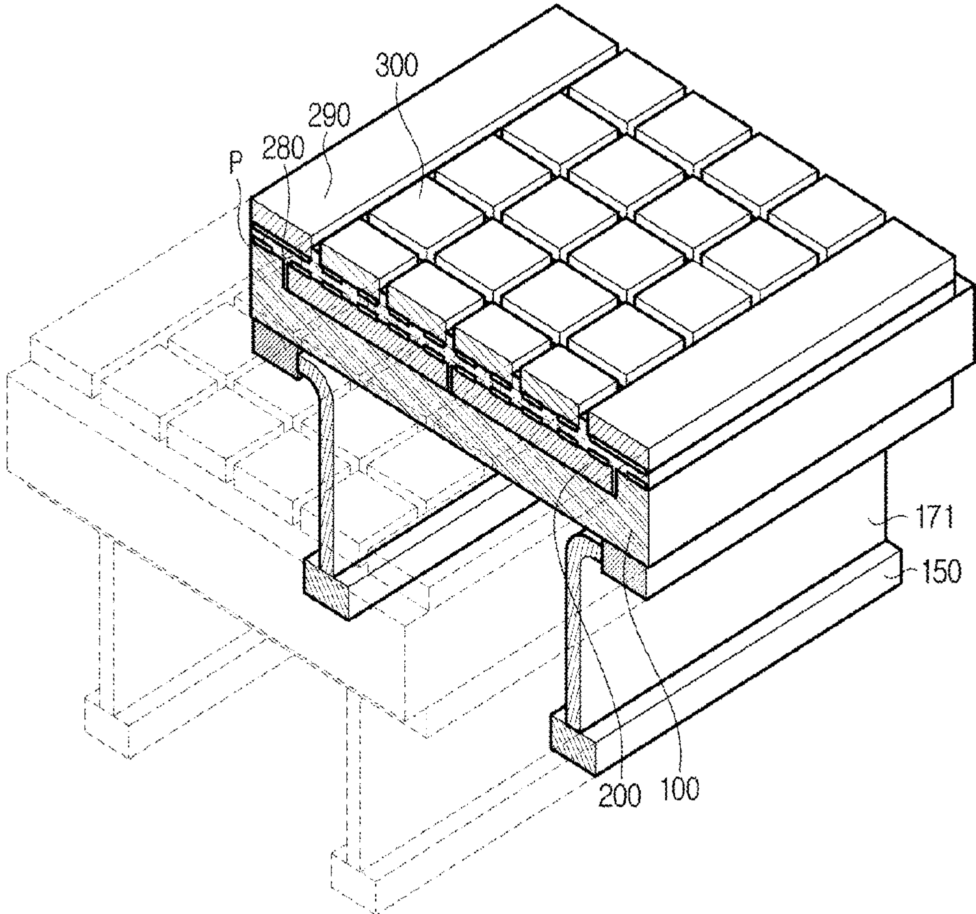


FIG. 4

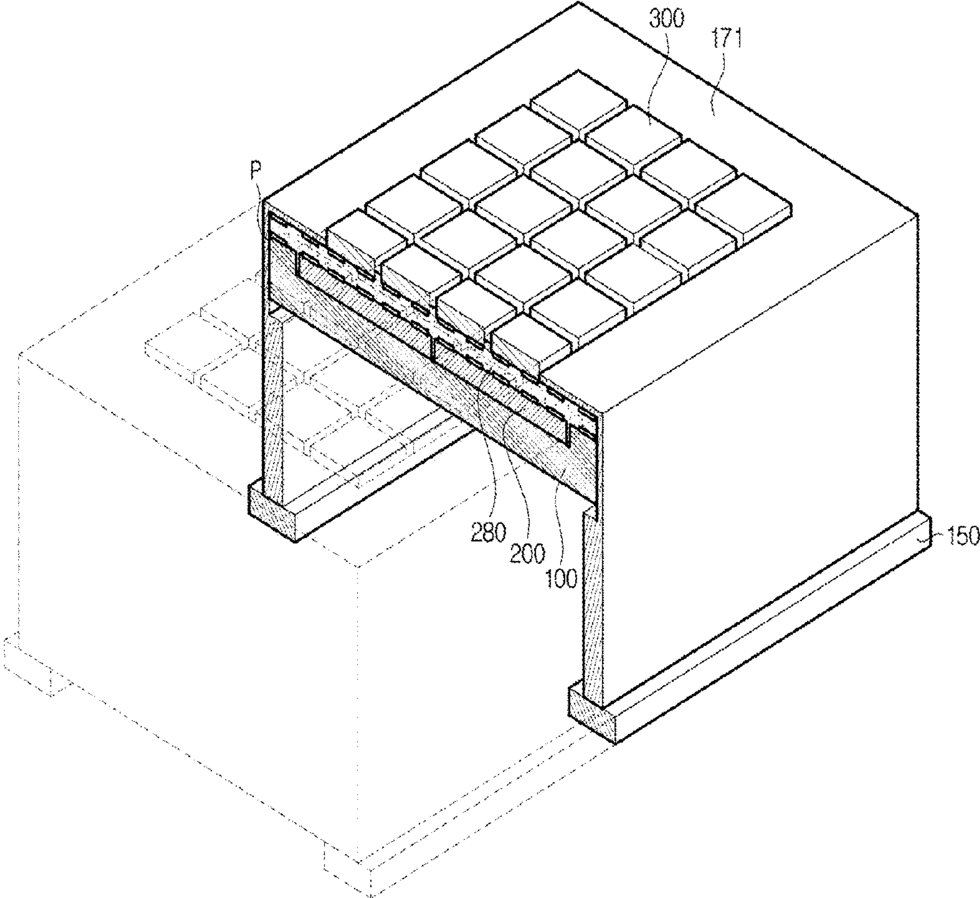


FIG. 5

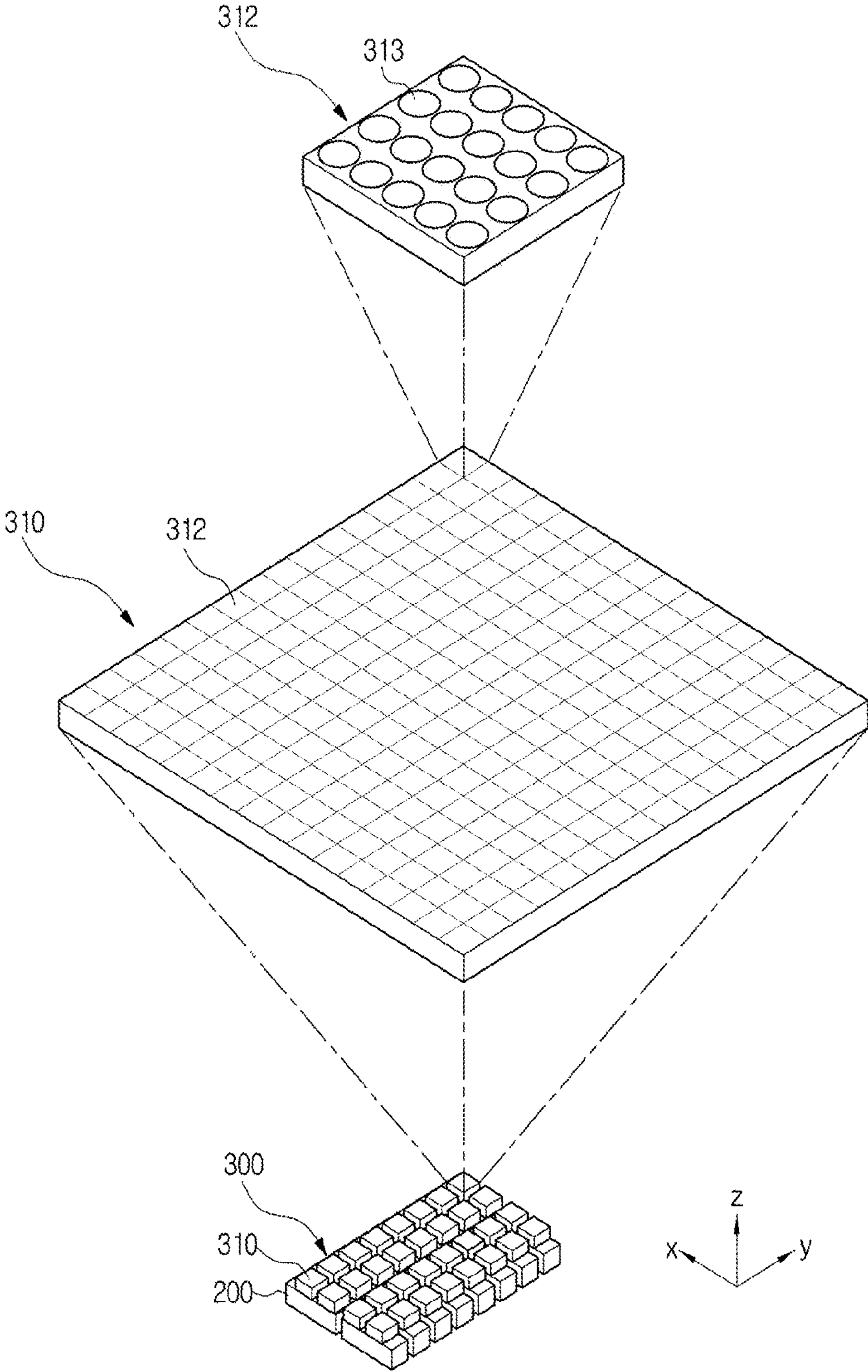


FIG. 6

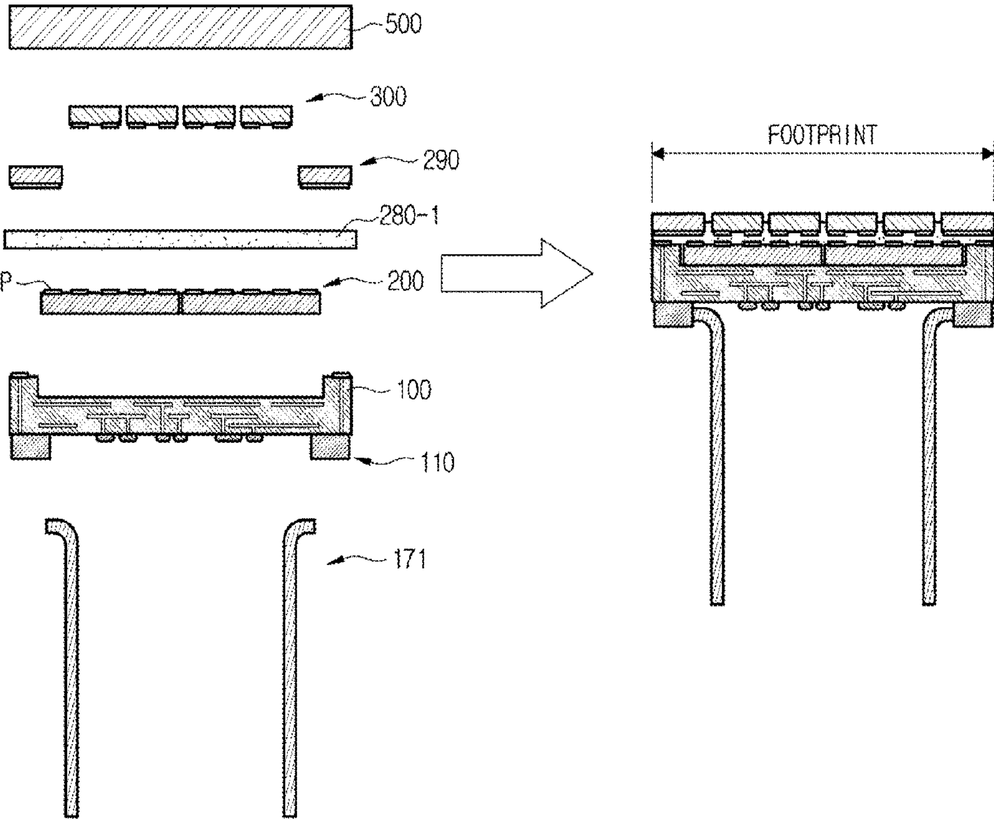


FIG. 7

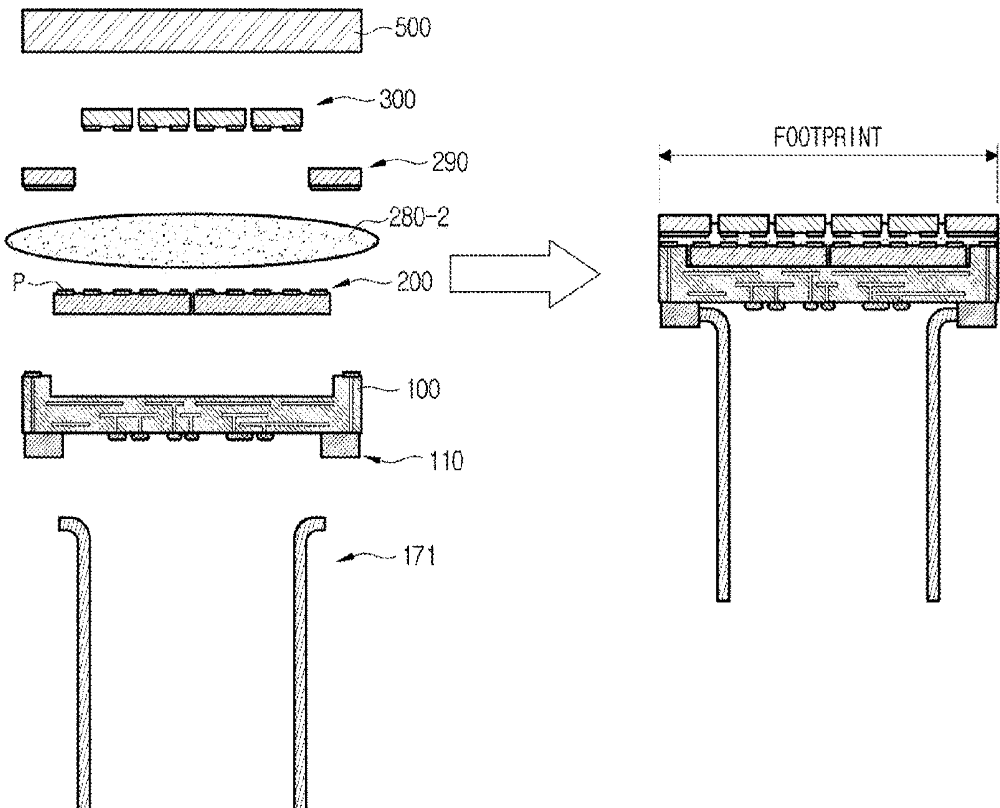


FIG. 8

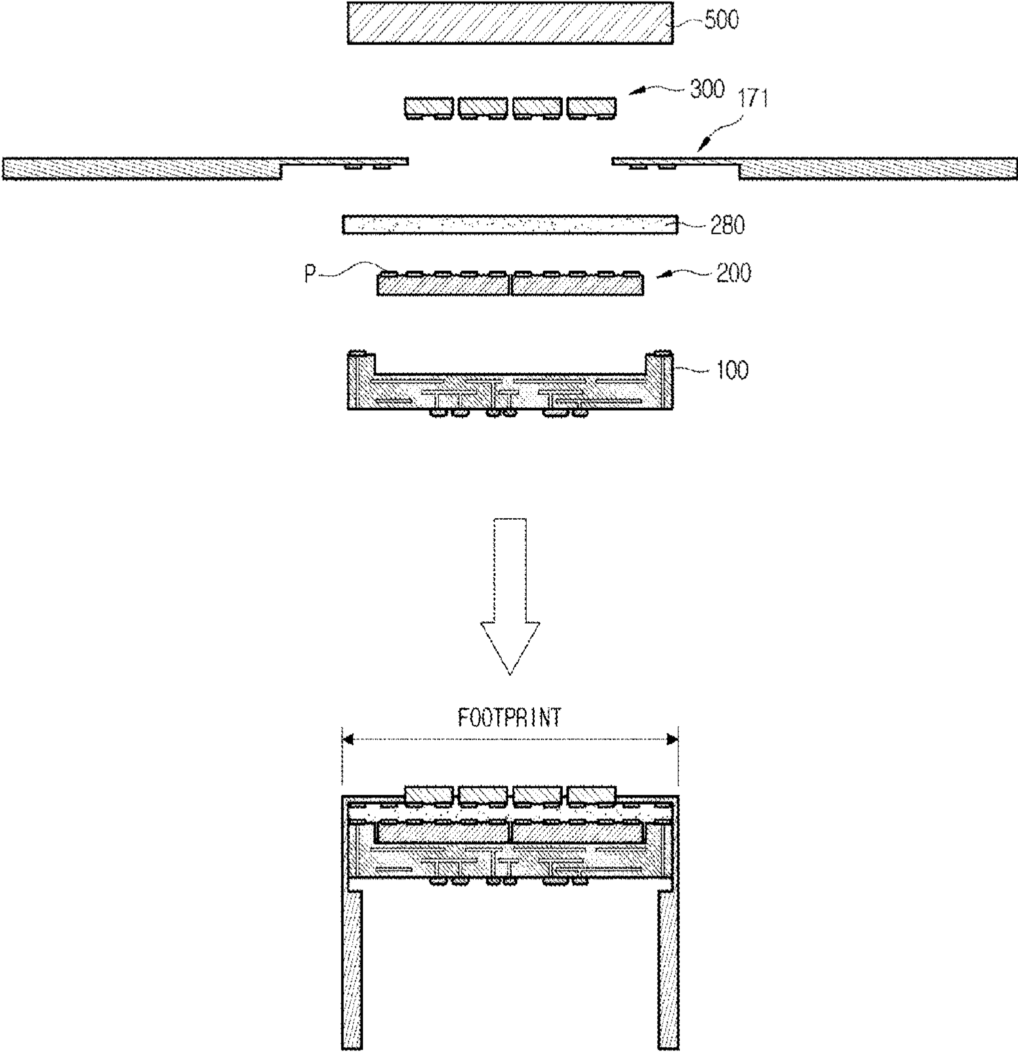


FIG. 9

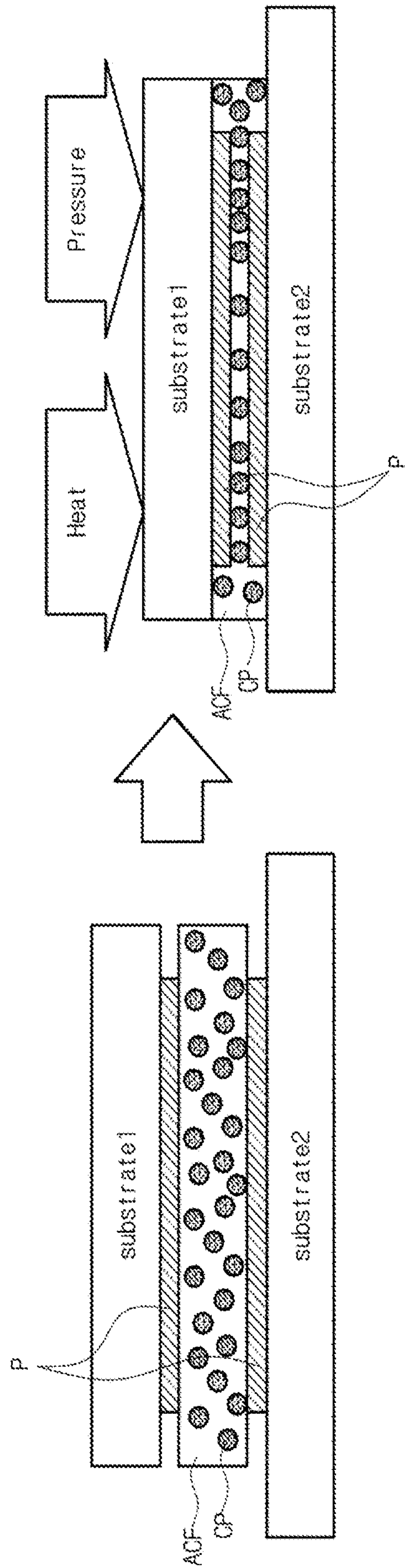


FIG. 10

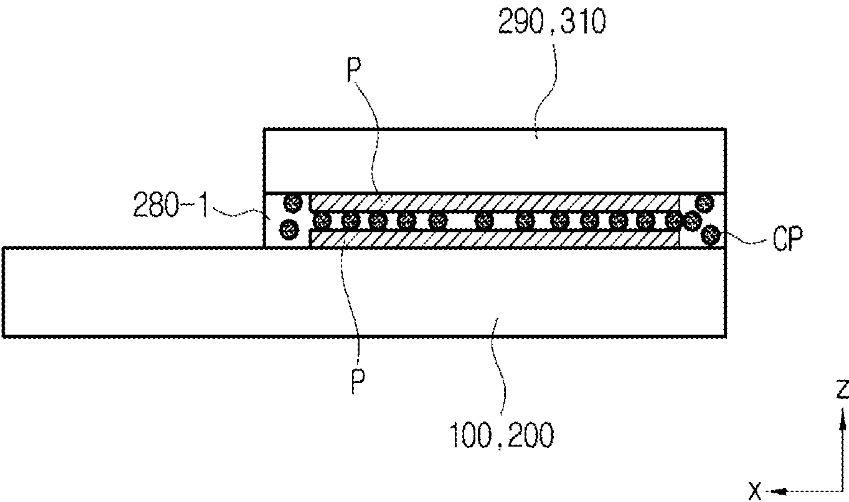
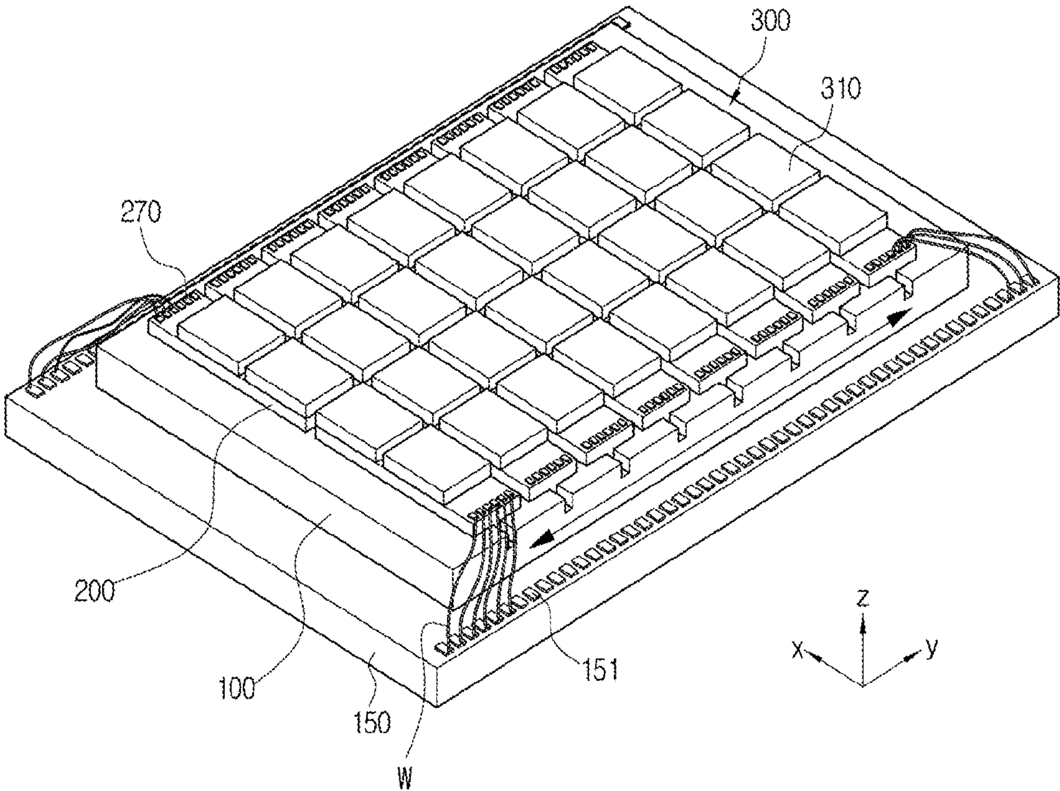


FIG. 11



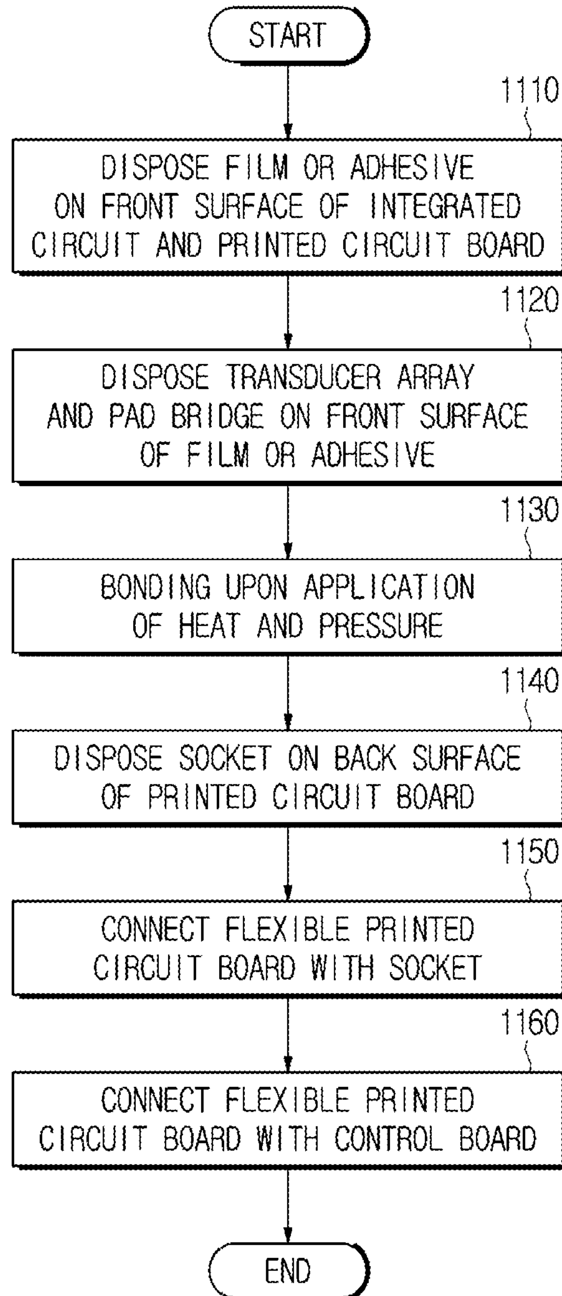


FIG. 12
START
1110
DISPOSE FILM OR ADHESIVE ON FRONT SURFACE OF INTEGRATED CIRCUIT AND PRINTED CIRCUIT BOARD
1120
DISPOSE TRANSDUCER ARRAY AND PAD BRIDGE ON FRONT SURFACE OF FILM OR ADHESIVE
1130
BONDING UPON APPLICATION OF HEAT AND PRESSURE
1140
DISPOSE SOCKET ON BACK SURFACE OF PRINTED CIRCUIT BOARD
1150
CONNECT FLEXIBLE PRINTED CIRCUIT BOARD WITH SOCKET
1160
CONNECT FLEXIBLE PRINTED CIRCUIT BOARD WITH CONTROL BOARD
END

ULTRASOUND PROBE AND MANUFACTURING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority from Korean Patent Application No. 10-2014-0077814, filed on Jun. 25, 2014 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] 1. Field

[0003] Exemplary embodiments relate to ultrasound probes.

[0004] 2. Description of the Related Art

[0005] An ultrasonic imaging apparatus is an apparatus which is configured to acquire a soft tissue tomogram or a blood stream image in a non-invasive method by emitting ultrasonic waves toward a target region in an object from the surface of the object and receiving echo ultrasonic waves reflected by the target region.

[0006] Since the ultrasonic imaging apparatus is small and inexpensive, displays an image in real time, and provides high safety owing to no X-ray exposure, as compared to other image diagnostic apparatuses such as an X-ray diagnosis apparatus, a computerized tomography (CT) scanner, a magnetic resonance imaging (MRI) apparatus, and a nuclear medicine diagnostic apparatus. Thus, the ultrasonic imaging apparatus has been widely used for performing heart diagnosis, celiac diagnosis, urinary diagnosis, and obstetric diagnosis.

[0007] The ultrasonic imaging apparatus includes an ultrasound probe which is configured to emit ultrasonic waves toward an object and to receive echo ultrasonic waves reflected by the object in order to acquire an image of the inside of the object.

SUMMARY

[0008] Therefore, it is an aspect of one or more exemplary embodiments to provide an ultrasound probe in which a transducer array and a pad bridge are connected to an integrated circuit and a printed circuit board.

[0009] It is another aspect of one or more exemplary embodiments to provide an ultrasound probe in which a transducer array and a flexible printed circuit board are connected to an integrated circuit and a printed circuit board.

[0010] Additional aspects will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the exemplary embodiments.

[0011] In accordance with one aspect of one or more exemplary embodiments, an ultrasound probe includes a transducer array configured to generate ultrasonic waves, an integrated circuit disposed on a back surface of the transducer array by using an adhesive member, a printed circuit board connected to the integrated circuit and configured to output a signal to the integrated circuit, and a pad bridge disposed on front surfaces of the printed circuit board and the integrated circuit by using the adhesive member and configured to electrically connect the printed circuit board with the integrated circuit.

[0012] The adhesive member may include at least one from among an anisotropic conductive film, an isotropic conductive film, and a non-conductive film.

[0013] The adhesive member may include at least one from among an anisotropic conductive adhesive, an isotropic conductive adhesive, and a non-conductive adhesive.

[0014] The transducer array, the pad bridge, the integrated circuit, and the printed circuit board may be bonded together by the adhesive member by using an application of heat and pressure.

[0015] The printed circuit board may include a cavity configured to support the integrated circuit.

[0016] The integrated circuit may include a first plurality of electrodes and the printed circuit board may include a second plurality of electrodes, and the pad bridge may be further configured to electrically connect the first plurality of electrodes with the second plurality of electrodes by using the adhesive member.

[0017] The ultrasound probe may further include a flexible printed circuit board which includes a first end connected to the back surface of the printed circuit board and which is configured to output a signal to the printed circuit board, and a control board connected to a second end of the flexible printed circuit board and configured to output a signal to the printed circuit board via the flexible printed circuit board.

[0018] In accordance with another aspect of one or more exemplary embodiments, an ultrasound probe includes a transducer array configured to generate ultrasonic waves, an integrated circuit disposed on a back surface of the transducer array by using an adhesive member, a printed circuit board connected to the integrated circuit and configured to output a signal to the integrated circuit, and a flexible printed circuit board which includes a first end connected to front surfaces of the printed circuit board and the integrated circuit by using the adhesive member.

[0019] The adhesive member may further include at least one from among an anisotropic conductive film, an isotropic conductive film, and a non-conductive film.

[0020] The adhesive member may further include at least one from among an anisotropic conductive adhesive, an isotropic conductive adhesive, and a non-conductive adhesive.

[0021] The transducer array, the flexible printed circuit board, the integrated circuit, and the printed circuit board may be bonded together by the adhesive member by using an application of heat and pressure.

[0022] The printed circuit board may include a cavity configured to support the integrated circuit.

[0023] The flexible printed circuit board may include an empty region, and the empty region is a region in which the transducer array is bonded to the integrated circuit.

[0024] In accordance with another aspect of one or more exemplary embodiments, a method for manufacturing an ultrasound probe includes disposing an adhesive member on front surfaces of an integrated circuit and a printed circuit board, disposing a transducer array configured to generate ultrasonic waves and a pad bridge configured to connect the integrated circuit with the printed circuit board on a front surface of the adhesive member, and bonding the integrated circuit, the printed circuit board, the pad bridge, and the transducer array by applying at least one from among heat and pressure.

[0025] The method may further include disposing a socket on a back surface of the printed circuit board, and disposing a flexible printed circuit board which includes a first end con-

nected to the socket, wherein the flexible printed circuit board is configured to output a signal to the printed circuit board.

[0026] The bonding may include bonding in a vacuum environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] These and/or other aspects will become apparent and more readily appreciated from the following description of exemplary embodiments, taken in conjunction with the accompanying drawings of which:

[0028] FIG. **1** is a perspective view exemplarily illustrating a configuration of an ultrasonic imaging apparatus;

[0029] FIG. **2** is a block diagram exemplarily illustrating the ultrasonic imaging apparatus;

[0030] FIGS. **3** and **4** are perspective views illustrating examples of a transducer module of an ultrasound probe, according to an exemplary embodiment;

[0031] FIG. **5** is an enlarged diagram illustrating a concept of configurations of transducer arrays of the transducer modules of FIGS. **3** and **4**;

[0032] FIGS. **6**, **7**, and **8** are cross-sectional views of examples of the transducer modules of the ultrasound probe, according to the illustrated exemplary embodiment;

[0033] FIG. **9** is a diagram illustrating a concept of bonding by using an anisotropic conductive film;

[0034] FIG. **10** is a diagram illustrating a concept of bonding of a cMUT array to an integrated circuit or bonding of a pad bridge to a printed circuit board or the integrated circuit by using an anisotropic conductive film;

[0035] FIG. **11** is a perspective view illustrating a transducer module having a stack structure in which a control board is connected to an integrated circuit by wires; and

[0036] FIG. **12** is a flowchart illustrating a method of manufacturing an ultrasound probe, according to an exemplary embodiment.

DETAILED DESCRIPTION

[0037] Reference will now be made in detail to exemplary embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In the description of the exemplary embodiments, certain detailed explanations of related art are omitted when it is deemed that they may unnecessarily obscure the essence of the exemplary embodiments. It will be understood that although the terms "first", "second", etc. may be used herein to describe various components, these components should not be limited by these terms. These components are only used to distinguish one component from another.

[0038] Hereinafter, exemplary embodiments will be described in detail with reference to the accompanying drawings.

[0039] FIG. **1** is a perspective view exemplarily illustrating a configuration of an ultrasonic imaging apparatus. FIG. **2** is a block diagram exemplarily illustrating the ultrasonic imaging apparatus.

[0040] Referring to FIGS. **1** and **2**, an ultrasonic imaging apparatus includes an ultrasound probe P configured to emit ultrasonic waves toward an object ob, receive echo ultrasonic waves from the object ob, and convert the received echo ultrasonic waves into electric signals (hereinafter, referred to as ultrasonic signals), and a main body M configured to generate an ultrasonic image based on the ultrasonic signals. As illustrated in FIG. **1**, the main body M may be a workstation connected to the ultrasound probe P and including an input unit (also referred to herein as an "input device") i and a display unit (also referred to herein as a "display device" and/or as a "display") d.

[0041] As illustrated in FIG. **2**, the main body M includes an image processor **400** which is configured to generate an image based on an ultrasonic signal output from the ultrasound probe P, a system memory **410** which is configured to store the ultrasonic image generated by the image processor **400**, a display unit d which is configured to display the ultrasonic image generated by the image processor **400** or the ultrasonic image stored in the system memory **410**, an ultrasonic wave generation controller **430** which is configured to control an emission of ultrasonic waves of a transducer module T, a power supply **450** which is configured to apply a predetermined alternating current to the transducer module T, an input unit i through which an instruction or command to control the ultrasonic imaging apparatus is input by a user, and a system controller **440** which is configured to control an overall operation of the ultrasonic imaging apparatus by controlling the ultrasonic wave generation controller **430**, the image processor **400**, the system memory **410**, and the display unit d.

[0042] The image processor **400** generates an image such that a user, e.g., a doctor or a patient, visually checks the object ob, e.g., the inside of a human body, based on the ultrasonic signal.

[0043] The image processor **400** transmits the ultrasonic image generated using the ultrasonic signal to the system memory **410** and/or to the display unit d.

[0044] In addition, the image processor **400** may further perform an additional image processing of the ultrasonic image. For example, the image processor **400** may further perform a post-processing operation, such as, for example, a correction or re-adjustment of contrast, brightness, and/or sharpness of the ultrasonic image.

[0045] In addition, one region of the ultrasonic image may be distinguished from the other region by using known techniques such as using different colors or a marker, or a 3-dimensional (3D) ultrasonic image may be created by generating a plurality of ultrasonic images. This additional image processing of the image processor **400** may be performed in accordance with predetermined settings or an instruction of command of the user input through the input unit i.

[0046] The system memory **410** stores the ultrasonic image generated by the image processor **400** or the post-processed ultrasonic image, and the display unit d displays the ultrasonic image generated by the image processor **400** or the ultrasonic image stored in the system memory **410** such that the user may visually check an inner structure or tissues of the object ob.

[0047] The ultrasonic wave generation controller **430** generates a transmit pulse in accordance with the command of the system controller **440**, and transmits the transmit pulse to the transducer module T. The transducer module T generates ultrasonic waves in accordance with the transmit pulse which is output from the ultrasonic wave generation controller **430** and emits the ultrasonic waves toward the object ob.

[0048] In addition, the ultrasonic wave generation controller **430** may generate a separate control signal for the power supply **450** such that the power supply **450** may apply a predetermined alternating current to the transducer module T.

[0049] The system controller **440** controls the overall operation of the ultrasonic imaging apparatus such as the ultrasonic wave generation controller **430**, the image processor **400**, the system memory **410**, and the display unit d.

[0050] According to the illustrated exemplary embodiment, the system controller **440** may control the operation of the ultrasonic imaging apparatus in accordance with the predetermined settings or after generating a predetermined control command according to an instruction or command of the user input through the input unit i.

[0051] The input unit i receives an instruction or command from the user to control the ultrasonic imaging apparatus. The input unit i may include a user interface, such as, for example, any one or more of a keyboard, mouse, trackball, touch screen, and/or paddle.

[0052] The ultrasound probe P collects information regarding a target region of the object ob by using ultrasonic waves.

[0053] Referring to FIG. **2**, the ultrasound probe P includes the transducer module T that generates ultrasonic waves, emits the ultrasonic waves toward the target region of the object ob, and receives echo ultrasonic waves.

[0054] The transducer module T generates ultrasonic waves in accordance with a pulse signal or alternating signal applied thereto and emits the ultrasonic waves toward the object ob. The ultrasonic waves emitted to the object ob are reflected by the target region. The transducer module T receives reflected echo ultrasonic waves and converts the received echo ultrasonic waves into electric signals, thereby generating ultrasonic signals.

[0055] The transducer module T receives power from an external power supplying device or an internal charge storage device, such as a battery. When power is supplied, a piezoelectric vibrator or a thin film constituting the transducer module T vibrates. The transducer module T emits the ultrasonic waves generated by vibration of the piezoelectric vibrator or the thin film to the object ob. When the echo ultrasonic waves reflected by the object ob are received, the piezoelectric vibrator or the thin film constituting the transducer module T vibrates in accordance with the echo ultrasonic waves. The transducer module T generates alternating current having a frequency corresponding to a vibration frequency of the piezoelectric vibrator or the thin film, thereby converting ultrasonic waves into electric signals (hereinafter, referred to as ultrasonic signals).

[0056] Hereinafter, the transducer module T will be described in more detail with reference to FIGS. **3** to **8**. FIGS. **3** and **4** are perspective views illustrating examples of the transducer module of the ultrasound probe, according to the illustrated exemplary embodiment. FIG. **5** is an enlarged diagram illustrating a concept of configurations of transducer arrays of the transducer modules of FIGS. **3** and **4**. FIGS. **6**, **7**, and **8** are cross-sectional views of examples of the transducer module of the ultrasound probe, according to the illustrated exemplary embodiment.

[0057] In particular, FIG. **6** is a cross-sectional view of a transducer module of an ultrasound probe bonded using a film **280-1**, FIG. **7** is a cross-sectional view of a transducer module of an ultrasound probe bonded using an adhesive **280-2**, and FIG. **8** is a cross-sectional view of a transducer module of an ultrasound probe realized using a flexible printed circuit board **171** instead of a pad bridge **290**.

[0058] Referring to FIG. **3**, the transducer module T includes: a transducer array **300** configured for transmitting and receiving ultrasonic waves; a pad bridge **290** which includes wiring blocks configured for electrical connection between integrated circuits **200** and a printed circuit board **100**; the integrated circuits **200** to which the transducer array **300** is bonded; the printed circuit board **100** and a flexible printed circuit board **171** which connect the integrated circuits **200** with a control board **150** in order to output a transmit signal output from the control board **150** to the integrated circuits **200**, and the control board **150** configured for outputting the transmit signal for generating ultrasonic waves to the integrated circuits **200**.

[0059] The transducer array **300** includes a plurality of transducer elements **312** that transmit and receive ultrasonic waves. Various types of ultrasonic transducers, such as a magnetostrictive ultrasonic transducer using a magnetostrictive effect of a magnetic material widely used in ultrasound probes, a piezoelectric ultrasonic transducer using a piezoelectric effect of a piezoelectric material, and a piezoelectric micromachined ultrasonic transducer (pMUT) may be used as the transducer element **312**. Furthermore, a capacitive micromachined ultrasonic transducer (cMUT), which transmits and receives ultrasonic waves by using vibration of hundreds or thousands of micromachined thin films, may also be used. According to the illustrated exemplary embodiment, a cMUT will be described as an example of the transducer element **312**.

[0060] The cMUT array **300** may include a two-dimensional (2D) array as illustrated in FIGS. **3** and **4**.

[0061] A tile **310** is a basic constituent unit of the cMUT array **300**. The tile **310** includes elements **312** arrayed in a 2D array form. The element **312** includes a plurality of thin films **313** which are arrayed in a 2D array form and which vibrate when an electric signal is applied thereto.

[0062] For example, as illustrated in FIG. **5**, the cMUT array **300** may have a 2D array form having a 4×8 size and may include 32 tiles **310**. One tile **310** may have a 2D array form which has a 16×16 size and which includes 256 elements **312**. One element **312** may include between 20 and 25 thin films **313** vibrating upon application of the electric signal in order to generate ultrasonic waves. In this case, the cMUT array **300** may include a total of between 163,840 and 204,800 thin films **313**.

[0063] As described above, when the cMUT array **300** that is a transducer of the ultrasound probe P has a 2D array form which has a 4×8 size and which includes 32 tiles **310**, two integrated circuits **200** configured for controlling electric signals respectively applied to two upper tiles **310** and two lower tiles **310** of each row of the cMUT array **300** may be bonded thereto.

[0064] For example, the cMUT array **300** may be bonded to the integrated circuits **200**, such as, for example, Application Specific Integrated Circuits (ASICs), via a film or adhesive **280**. The integrated circuits **200** to which the cMUT array **300** is bonded may be connected to the control board **150** via the printed circuit board **100** and the flexible printed circuit board **171**. This will be described below. When the transmit signal is applied through the control board **150**, the integrated circuits **200** may control generation of ultrasonic waves by controlling the transmit signal applied to the cMUT array **300** in accordance with a logic. The transmit signal applied from the control board **150** may be a transmit pulse output from the ultrasonic wave generation controller **430** of the main body M. According to another exemplary embodiment, the control board **150** may directly generate a transmit pulse and output

the transmit pulse to the integrated circuits **200** via the printed circuit board **100** and the flexible printed circuit board **171**.

[0065] The film **280-1** refers to a very thin layer of a solid attached to the surface of an object, and the adhesive **280-2** refers to a material used to bond objects and solidified from a liquid state. Both of the film **280-1** and the adhesive **280-2** may be regarded as an adhesive member **280**.

[0066] The printed circuit board **100** is electrically connected to the integrated circuits **200** via the film or adhesive **280**, thereby transmitting the transmit signal output from the control board **150** to the integrated circuits **200**. In addition, as illustrated in FIGS. **3**, **4**, **6**, **7**, and **8**, the printed circuit board **100** may have a cavity in which the integrated circuits **200** are disposed, and a surface of a non-cavity region of the printed circuit board **100** bonded to the film or adhesive **280** may have a height identical to those of the integrated circuits **200** bonded to the film or adhesive **280**. In particular, the printed circuit board **100** may have a height-leveled surface bonded to the film or adhesive **280**.

[0067] Meanwhile, in addition to the bonding to the film or adhesive **280** by forming the cavity in the printed circuit board **100**, the printed circuit board **100** may also be bonded to the film or adhesive **280** by disposing a pad (not shown) having the same height as those of the integrated circuits **200** disposed on the front surface of the printed circuit board **100**, without being limited thereto.

[0068] In addition, the printed circuit board **100** may include a plurality of electrodes P at both ends thereof. The plurality of electrodes P transmit the transmit signal to electrodes P of the integrated circuits **200** via the film or adhesive **280** bonded to the printed circuit board **100** and the integrated circuits **200**.

[0069] The integrated circuits **200** may control a generation of ultrasonic waves by controlling the transmit signal applied to the cMUT array **300** in accordance with a logic. The integrated circuits **200** may include electrodes P connected to the printed circuit board **100** at both ends. In particular, the electrodes E of the integrated circuits **200** receive the transmit signal from the electrodes E of the printed circuit board **100** via the film or adhesive **280** bonded to the printed circuit board **100** and the integrated circuits **200**.

[0070] The transducer module T according to the illustrated exemplary embodiment may include the pad bridge **290**. The pad bridge **290** connects the printed circuit board **100** with the integrated circuits **200** via the film or adhesive **280**, as illustrated in FIGS. **3**, **6**, and **7**. In particular, the pad bridge **290** is bonded to the front surfaces of the printed circuit board **100** and the integrated circuits **200** via the film or adhesive **280**, and may include wiring blocks for electrical connection between the integrated circuits **200** and the printed circuit board **100**.

[0071] In addition, the pad bridge **290** may enable transmission of the transmit signal from an electrode P of the printed circuit board **100** not only to electrodes P of one integrated circuit **200** adjacent thereto in the X-axis, but also to electrodes P of the other integrated circuit **200**. In the same manner, any one of the electrodes E of the integrated circuits **200** may be connected to any one of the electrodes E of the printed circuit board **100** via the pad bridge **290**.

[0072] Since the pad bridge **290** is connected to the plurality of electrodes P of the printed circuit board **100** and the integrated circuits **200** via the film or adhesive **280**, an unnecessary area which might otherwise be required for complex wirings respectively connecting the electrodes E of the printed circuit board **100** with the electrodes E of the integrated circuits **200** may be reduced.

[0073] The flexible printed circuit board **171** transmits the transmit signal output from the control board **150** to the printed circuit board **100**. In particular, since one end of the flexible printed circuit board **171** is connected to the back surface of the printed circuit board **100**, and the other end of the flexible printed circuit board **171** is connected to the control board **150**, the transmit signal output from the control board **150** may be transmitted to the printed circuit board **100**, and thus the transmit signal is transmitted to the integrated circuits **200**. The control board **150** may be implemented using a printed circuit board on which electronic devices for generating the transmit signal and processing the ultrasonic signal are mounted.

[0074] The other end of the flexible printed circuit board **171** may be connected to the control board **150** via any of various known connectors, or may be connected to electrodes of the control board **150** via an anisotropic conductive film **280-1**.

[0075] As a connector to electrically connect the flexible printed circuit board **171** with the printed circuit board **100**, a separate socket **110** may be disposed on the back surface of the printed circuit board **100**.

[0076] Meanwhile, in the transducer module T according to another exemplary embodiment, the flexible printed circuit board **171**, instead of the pad bridge **290**, may be disposed on the front surfaces of the printed circuit board **100** and the integrated circuits **200**, such that the flexible printed circuit board **171** may perform functions of both of the pad bridge **290** and the flexible printed circuit board **171** as illustrated in FIGS. **4** and **8**.

[0077] In particular, since the flexible printed circuit board **171** is bonded to the front surfaces of the printed circuit board **100** and the integrated circuits **200**, the transmit signal may be transmitted to the printed circuit board **100** via the film or adhesive **280**, and the printed circuit board **100** and the integrated circuits **200** are connected to each other via the film or adhesive **280**.

[0078] In addition, as illustrated in FIGS. **4** and **8**, two flexible printed circuit boards **171** may be disposed on both sides of the cMUT array **300**. However, exemplary embodiments are not limited thereto, one flexible printed circuit board **171** having an empty region may also be used. In particular, the empty region may be the bonding surface of the film or adhesive **280** between the cMUT array **300** and the integrated circuits **200**.

[0079] As illustrated in FIGS. **3** and **4**, the control board **150** may be disposed at the back side of the printed circuit board **100** to be perpendicular to the printed circuit board **100** and the integrated circuits **200**, without being limited thereto.

[0080] Meanwhile, referring to FIGS. **6**, **7**, and **8**, the transducer module T may further include a leveling unit (also referred to herein as a "leveler") **500**, and the leveling unit **500** is configured to level the height of the film or adhesive **280** with respect to the surface of the cMUT array **300**. In this aspect, the film or adhesive **280** functions as a cushion for a height difference of the surface of the cMUT array **300**.

[0081] The film **280-1** may include any of an anisotropic conductive film (ACF), an isotropic conductive film (ICF), or a non-conductive film (NCF), and the adhesive **280-2** may include any of an anisotropic conductive adhesive (ACA), an isotropic conductive adhesive (ICA), or a non-conductive adhesive (ICA), without being limited thereto.

[0082] Hereinafter, the anisotropic conductive film **280-1**, which bonds the back surface of the cMUT array **300** to the front surfaces of the printed circuit board **100** and the integrated circuits **200**, will be described.

[0083] FIG. **9** is a diagram illustrating a concept of bonding by using the anisotropic conductive film **280-1**. FIG. **10** is a diagram illustrating a concept of bonding of the cMUT array **300** to the integrated circuits **200** or bonding of the pad bridge **290** to the printed circuit board **100** or the integrated circuits **200** by using the anisotropic conductive film **280-1**.

[0084] In the anisotropic conductive film **280-1**, conductive particles CP are dispersed in a film-shaped thermosetting epoxy resin or acrylic resin. Various electronic parts are mechanically or electrically bonded together by the anisotropic conductive film **280-1** through a process of applying heat and pressure.

[0085] As illustrated in FIG. **9**, the anisotropic conductive film ACF **280-1** is disposed between electrodes P of objects to be bonded to each other, e.g., "substrate 1" and "substrate 2". When heat and pressure are applied to the substrate 1, the substrate 1 and the substrate 2 are not only mechanically bonded to each other by the anisotropic conductive film ACF **280-1**, but are also electrically connected to each other by the conductive particles CP dispersed in the anisotropic conductive film ACF **280-1**.

[0086] Hereinafter, the anisotropic conductive film **280-1** will be described with reference to the structure including the pad bridge **290** illustrated in FIGS. **3** and **6**. According to another exemplary embodiment, in the transducer module T including the flexible printed circuit board **171** illustrated in FIGS. **4** and **8**, the pad bridge **290** may be implemented by using the flexible printed circuit board **171**.

[0087] As illustrated in FIG. **10**, when the anisotropic conductive film **280-1** is disposed between the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290**, and heat and pressure are applied to the printed circuit board **100** or the pad bridge **290**, the anisotropic conductive film **280-1** has fluidity. In addition, the conductive particles CP disposed between the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290** are physically connected to the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290**, so that the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290** are electrically connected to each other.

[0088] When the anisotropic conductive film **280-1** is hardened, the pad bridge **290** is mechanically attached to the printed circuit board **100**. The conductive particles CP of the anisotropic conductive film **280-1** electrically connects the electrodes E of the printed circuit board **100** with the electrodes E of the pad bridge **290**. A signal output from the printed circuit board **100** is transmitted to the pad bridge **290** by the conductive particles CP.

[0089] In addition, when the anisotropic conductive film **280-1** is disposed between the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200**, and heat and pressure are applied to the integrated circuits **200** or the pad bridge **290**, the anisotropic conductive film **280-1** has fluidity. In addition, the conductive particles CP disposed between the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200** are physically connected to the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200**, so that the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200** are electrically connected to each other.

[0090] When the anisotropic conductive film **280-1** is hardened, the integrated circuits **200** are mechanically attached to the pad bridge **290**. In addition, the conductive particles CP of the anisotropic conductive film **280-1** electrically connect the electrodes E of the pad bridge **290** with the electrodes E of the integrated circuits **200**. A signal output from the pad bridge **290** is transmitted to the integrated circuits **200** by the conductive particles CP.

[0091] In addition, when the anisotropic conductive film **280-1** is disposed between the electrodes E of the integrated circuits **200** and the electrodes of the cMUT array **300**, and heat and pressure are applied to the integrated circuits **200** or the cMUT array **300**, the anisotropic conductive film **280-1** has fluidity. In addition, the conductive particles CP disposed between the electrodes E of the integrated circuits **200** and the electrodes of the cMUT array **300** are physically connected to the electrodes E of the integrated circuits **200** and the electrodes E of the cMUT array **300**, so that the electrodes E of the integrated circuits **200** and the electrodes E of the cMUT array **300** are electrically connected to each other.

[0092] When the anisotropic conductive film **280-1** is hardened, the cMUT array **300** is mechanically attached to the integrated circuits **200**. In addition, the conductive particles CP of the anisotropic conductive film **280-1** electrically connect the electrodes E of the integrated circuits **200** with the electrodes E of the cMUT array **300**. A signal output from the integrated circuits **200** is transmitted to the cMUT array **300** by the conductive particles CP.

[0093] Meanwhile, when a bonding process of the anisotropic conductive film **280-1** is performed in a vacuum environment, air-voids may be minimized in a bonding interface, thereby improving mechanical reliability. By using this bonding process of the anisotropic conductive film **280-1**, an underfill process, which may be performed in a conventional flip-chip process by soldering, may be omitted.

[0094] FIG. **11** is a perspective view illustrating a transducer module having a stack structure in which a control board and integrated circuits are connected by wires.

[0095] As illustrated in FIG. **11**, in general, the stack structure is formed by installing the control board **150** on the back surface of the integrated circuits **200** to be parallel to the integrated circuits **200**. In addition, the integrated circuits **200** are connected to the control board **150** via wires W. In this regard, the control board **150** has an area larger than a total area of the integrated circuits **200** as illustrated in FIG. **11**, such that the electrodes E of the integrated circuits **200** are connected to the control board **150** by wiring.

[0096] When a transducer module T is manufactured as illustrated in FIG. **11**, a length of the integrated circuits **200** in the X-axial direction is about 2.6 cm, and a length of the control board **150** in the X-axial direction is about 5 cm, which is about twice the length of the integrated circuits **200**. In this case, a length of a footprint of the ultrasound probe P in the X-axial direction is increased to about 5 cm or greater from 3 cm or less, thereby causing a reduction in transmission and reception efficiency.

[0097] In addition, when the integrated circuits **200** are connected to the control board **150** by wiring, the area of the control board **150** should be greater than a total area of the integrated circuits **200** in order to prevent interference among

the wirings W and reduce difficulty of the process, so that transmission and reception efficiency may further be reduced.

[0098] According to one or more exemplary embodiments, the integrated circuits **200** are connected to the control board **150** not by wirings W, but instead, the cMUT array **300**, the integrated circuits **200**, the printed circuit board **100**, and the pad bridge **290** are integrally connected by the film or adhesive **280**, so that difficulty of the process caused by wiring may be reduced. In addition, when the cMUT array **300**, the integrated circuits **200**, the pad bridge **290**, and the printed circuit board **100** are integrally connected using the film or adhesive **280**, an area of a region of the ultrasound probe P which contacts the human body (i.e., a footprint) may be prevented from increasing to be greater than that of the integrated circuits **200**.

[0099] FIG. **12** is a flowchart illustrating a method of manufacturing an ultrasound probe P, according to an exemplary embodiment.

[0100] Referring to FIG. 12, in operation **1110**, the film or adhesive **280** is disposed on the front surfaces of the integrated circuits **200** and the printed circuit board **100**, and the cMUT array **300** and the pad bridge **290** connecting the integrated circuits **200** with the printed circuit board **100** are disposed on the front surface of the film or adhesive **280** in operation **1120**. At least one of heat and pressure is applied thereto in order to bond the integrated circuits **200**, the printed circuit board **100**, the pad bridge **290**, and the cMUT array **300** together in operation **1130**. Meanwhile, when the flexible printed circuit board **171** is disposed on the front surface of the film or adhesive **280** instead of the pad bridge **290**, the film or adhesive **280** is disposed on the front surfaces of the integrated circuits **200** and the printed circuit board **100** in operation **1110**, and the cMUT array **300** generating ultrasonic waves and the flexible printed circuit board **171** are disposed on the front surface of the film or adhesive **280** in operation **1120**. At least one of heat and pressure is applied to bond the integrated circuits **200**, the printed circuit board **100**, the flexible printed circuit board **171**, and the cMUT array **300** together in operation **1130**.

[0101] Hereinafter, a description will be given of the pad bridge **290** disposed on the front surfaces of the printed circuit board **100** and the integrated circuits **200**.

[0102] The cMUT array **300** may be bonded to the integrated circuits **200**, such as Application Specific Integrated Circuits (ASICs), by using the film or adhesive **280**. As described above, when the cMUT array **300**, which is a transducer of the ultrasound probe P, has a 2D array form which has a 4×8 size and which includes 32 tiles **310**, two integrated circuits **200** may be bonded thereto in order to control electrical signals respectively applied to two upper tiles **310** and two lower tiles **310** in each row of the cMUT array **300**.

[0103] The printed circuit board **100** may be electrically connected to the integrated circuits **200** via the film or adhesive **280**, thereby transmitting a transmit signal output from the control board **150** to the integrated circuits **200**. In addition, as illustrated in FIGS. **3**, **4**, **6**. **7**, and **8**, the printed circuit board **100** may have a cavity in which the integrated circuits **200** are disposed, and a surface of a non-cavity region of the printed circuit board **100** bonded to the film or adhesive **280** may have a height which is identical to those of the integrated circuits **200** bonded to the film or adhesive **280**. In addition to the bonding to the film or adhesive **280** by forming the cavity in the printed circuit board **100**, the printed circuit board **100** may also be bonded to the film or adhesive **280** by disposing a pad (not shown) having the same height as those of the integrated circuits **200** disposed on the front surface of the printed circuit board **100**, without being limited thereto.

[0104] The integrated circuits **200** may control generation of ultrasonic waves by controlling the transmit signal applied to the cMUT array **300** in accordance with a logic. The electrodes E of the integrated circuits **200** receive the transmit signal from the electrodes E of the printed circuit board **100** via the film or adhesive **280** bonded to the printed circuit board **100** and the integrated circuits **200**.

[0105] The pad bridge **290** is bonded to the front surfaces of the printed circuit board **100** and the integrated circuits **200** by using the film or adhesive **280**, and may include wiring blocks for electrical connection between the integrated circuits **200** and the printed circuit board **100**.

[0106] Next, a socket **110** is disposed on the back surface of the printed circuit board **100** in operation **1140**, one end of the flexible printed circuit board **171** is connected to the socket **110** of the printed circuit board **100** in operation **1150**, and the other end of the flexible printed circuit board **171** is connected to the control board **150**. Thus, the transmit signal output from the control board **150** may be transmitted to the printed circuit board **100** in operation **1160**.

[0107] However, when the flexible printed circuit board **171** is disposed on the front surfaces of the printed circuit board **100** and the integrated circuits **200**, one end of the flexible printed circuit board **171** may be connected to the printed circuit board **100** and the integrated circuits **200** via the film or adhesive **280**, and the other end of the flexible printed circuit board **171** may be connected to the control board **150**. Thus, the transmit signal output from the control board **150** may be transmitted to the printed circuit board **100**.

[0108] The control board **150** may be implemented using the flexible printed circuit board **171** on which electronic devices configured to generate the transmit signal and process the ultrasonic signal are mounted. In this case, the flexible printed circuit board **171** may be mounted after mounting the control board **150**. Alternatively, the control board **150** may be mounted after the flexible printed circuit board **171** is bonded to the integrated circuits **200**. In this aspect, the manufacturing order is not limited to the aforementioned descriptions and may vary.

[0109] The film **280-1** may include any of an anisotropic conductive film (ACF), an isotropic conductive film (ICF), or a non-conductive film (NCF), and the adhesive **280-2** may include any of an anisotropic conductive adhesive (ACA), an isotropic conductive adhesive (ICA), or a non-conductive adhesive (ICA), without being limited thereto.

[0110] In the anisotropic conductive film **280-1**, conductive particles CP are dispersed in a film-shaped thermosetting epoxy resin or acrylic resin. Various electronic parts are mechanically or electrically bonded together by the anisotropic conductive film **280-1** through a process of applying heat and pressure.

[0111] As illustrated in FIG. **10**, when the anisotropic conductive film **280-1** is disposed between the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290**, and heat and pressure are applied to the printed circuit board **100** or the pad bridge **290**, the anisotropic conductive film **280-1** has fluidity. In addition, the conductive particles CP disposed between the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290** are physically connected to the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290**,

so that the electrodes E of the printed circuit board **100** and the electrodes E of the pad bridge **290** are electrically connected to each other.

[0112] When the anisotropic conductive film **280-1** is hardened, the pad bridge **290** is mechanically attached to the printed circuit board **100**. The conductive particles CP of the anisotropic conductive film **280-1** electrically connects the electrodes E of the printed circuit board **100** with the electrodes E of the pad bridge **290**. A signal output from the printed circuit board **100** is transmitted to the pad bridge **290** by the conductive particles CP.

[0113] In addition, when the anisotropic conductive film **280-1** is disposed between the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200**, and heat and pressure are applied to the integrated circuits **200** or the pad bridge **290**, the anisotropic conductive film **280-1** has fluidity. In addition, the conductive particles CP disposed between the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200** are physically connected to the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200**, so that the electrodes E of the pad bridge **290** and the electrodes E of the integrated circuits **200** are electrically connected to each other.

[0114] When the anisotropic conductive film **280-1** is hardened, the integrated circuits **200** are mechanically attached to the pad bridge **290**. In addition, the conductive particles CP of the anisotropic conductive film **280-1** electrically connect the electrodes E of the pad bridge **290** with the electrodes E of the integrated circuits **200**. A signal output from the pad bridge **290** is transmitted to the integrated circuits **200** by the conductive particles CP.

[0115] In addition, when the anisotropic conductive film **280-1** is disposed between the electrodes E of the integrated circuits **200** and the electrodes of the cMUT array **300**, and heat and pressure are applied to the integrated circuits **200** or the cMUT array **300**, the anisotropic conductive film **280-1** has fluidity. In addition, the conductive particles CP disposed between the electrodes E of the integrated circuits **200** and the electrodes of the cMUT array **300** are physically connected to the electrodes E of the integrated circuits **200** and the electrodes E of the cMUT array **300**, so that the electrodes E of the integrated circuits **200** and the electrodes E of the cMUT array **300** are electrically connected to each other.

[0116] When the anisotropic conductive film **280-1** is hardened, the cMUT array **300** is mechanically attached to the integrated circuits **200**. In addition, the conductive particles CP of the anisotropic conductive film **280-1** electrically connect the electrodes E of the integrated circuits **200** with the electrodes E of the cMUT array **300**. A signal output from the integrated circuits **200** is transmitted to the cMUT array **300** by the conductive particles CP.

[0117] Meanwhile, when a bonding process of the anisotropic conductive film **280-1** is performed in a vacuum environment, air-voids may be minimized in a bonding interface, thereby improving mechanical reliability. By using this bonding process of the anisotropic conductive film **280-1**, an underfill process, which is typically performed in a conventional flip-chip process by soldering, may be omitted.

[0118] As such, when the cMUT array **300**, the integrated circuits **200**, the printed circuit board **100**, and the pad bridge **290** are integrally bonded by using the film or adhesive **280**, difficulty of the process caused by wiring may be reduced. In addition, when the cMUT array **300**, the integrated circuits **200**, the pad bridge **290**, and the printed circuit board **100** are integrally connected by using the film or adhesive **280**, an area of a region of the ultrasound probe P which contacts the human body (footprint) may be prevented from increasing to be greater than that of the integrated circuits **200**

[0119] As is apparent from the above description, according to exemplary embodiments, an area of a region of the ultrasound probe contacting the human body may be reduced without reducing the size of the cMUT array.

[0120] Furthermore, the integrated circuit and the printed circuit board are integrally connected not by wiring but by using the adhesive member, and thus the difficulty of the process may be reduced.

[0121] Although a few exemplary embodiments have been shown and described, it will be appreciated by those of skill in the art that changes may be made in these exemplary embodiments without departing from the principles and spirit of the present disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An ultrasound probe comprising:

a transducer array configured to generate ultrasonic waves;

an integrated circuit disposed on a back surface of the transducer array by using an adhesive member;

a printed circuit board connected to the integrated circuit and configured to output a signal to the integrated circuit; and

a pad bridge disposed on front surfaces of the printed circuit board and the integrated circuit by using the adhesive member and configured to electrically connect the printed circuit board with the integrated circuit.

2. The ultrasound probe according to claim **1**, wherein the adhesive member comprises at least one from among an anisotropic conductive film, an isotropic conductive film, and a non-conductive film.

3. The ultrasound probe according to claim **1**, wherein the adhesive member comprises at least one from among an anisotropic conductive adhesive, an isotropic conductive adhesive, and a non-conductive adhesive.

4. The ultrasound probe according to claim **1**, wherein the transducer array, the pad bridge, the integrated circuit, and the printed circuit board are bonded together by the adhesive member by using an application of heat and pressure.

5. The ultrasound probe according to claim **1**, wherein the printed circuit board includes a cavity configured to support the integrated circuit.

6. The ultrasound probe according to claim **1**, wherein the integrated circuit comprises a first plurality of electrodes and the printed circuit board comprises a second plurality of electrodes, and

the pad bridge is further configured to electrically connect the first plurality of electrodes with the second plurality of electrodes by using the adhesive member.

7. The ultrasound probe according to claim **1**, further comprising:

a flexible printed circuit board which includes a first end connected to the back surface of the printed circuit board and which is configured to output a signal to the printed circuit board; and

a control board connected to a second end of the flexible printed circuit board and configured to output a signal to the printed circuit board via the flexible printed circuit board.

8. An ultrasound probe comprising:
a transducer array configured to generate ultrasonic waves;
an integrated circuit disposed on a back surface of the transducer array by using an adhesive member;
a printed circuit board connected to the integrated circuit and configured to output a signal to the integrated circuit; and
a flexible printed circuit board which includes a first end connected to front surfaces of the printed circuit board and the integrated circuit by using the adhesive member.

9. The ultrasound probe according to claim **8**, wherein the adhesive member comprises at least one from among an anisotropic conductive film, an isotropic conductive film, and a non-conductive film.

10. The ultrasound probe according to claim **8**, wherein the adhesive member comprises at least one from among an anisotropic conductive adhesive, an isotropic conductive adhesive, and a non-conductive adhesive.

11. The ultrasound probe according to claim **8**, wherein the transducer array, the flexible printed circuit board, the integrated circuit, and the printed circuit board are bonded together by the adhesive member by using an application of heat and pressure.

12. The ultrasound probe according to claim **8**, wherein the printed circuit board includes a cavity configured to support the integrated circuit.

13. The ultrasound probe according to claim **8**, wherein the flexible printed circuit board includes an empty region, and the empty region is a region in which the transducer array is bonded to the integrated circuit.

14. A method for manufacturing an ultrasound probe, the method comprising:
disposing an adhesive member on front surfaces of an integrated circuit and a printed circuit board;
disposing a transducer array configured to generate ultrasonic waves and a pad bridge configured to connect the integrated circuit with the printed circuit board on a front surface of the adhesive member; and
bonding the integrated circuit, the printed circuit board, the pad bridge, and the transducer array by applying at least one from among heat and pressure.

15. The method according to claim **14**, further comprising:
disposing a socket on a back surface of the printed circuit board; and
disposing a flexible printed circuit board which includes a first end connected to the socket, wherein the flexible printed circuit board is configured to output a signal to the printed circuit board.

16. The method according to claim **14**, wherein the bonding comprises bonding in a vacuum environment.

* * * * *

patsnap

专利名称(译)	超声探头及其制造方法		
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当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
[标]发明人	LEE EUNSUNG KIM YOUNGIL SONG JONG KEUN CHOI MINSEOG		
发明人	LEE, EUNSUNG KIM, YOUNGIL SONG, JONG KEUN CHOI, MINSEOG		
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摘要(译)

本发明公开了一种超声探头，包括：换能器阵列，被配置为产生超声波;集成电路，通过使用粘合构件设置在换能器阵列的后表面上;印刷电路板，连接到集成电路并且被配置为输出信号到所述集成电路和垫桥通过使用所述粘合构件设置在所述印刷电路板和所述集成电路的前表面上，并且被配置为将所述印刷电路板与所述集成电路电连接。可以在不减小换能器阵列的尺寸的情况下减小超声探头的接触人体的区域的面积，并且可以通过使用粘合构件将集成电路和印刷电路板一体地连接。