US008547799B2

(12) United States Patent
Rhim et al.

(10) **Patent No.: US 8,547,799 B2**

(45) **Date of Patent: Oct. 1, 2013**

(54) **ULTRASONIC PROBE, ULTRASONIC IMAGING APPARATUS AND FABRICATING METHOD THEREOF**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 832 days.

(21) Appl. No.: **12/699,166**

(22) Filed: **Feb. 3, 2010**

(65) **Prior Publication Data**

US 2010/0204583 A1 Aug. 12, 2010

(30) **Foreign Application Priority Data**

Feb. 10, 2009 (KR) 10-2009-0010661

(51) **Int. Cl.**
H04R 17/00 (2006.01)

(52) **U.S. Cl.**
USPC **367/155**

(58) **Field of Classification Search**
USPC 310/334, 322, 326, 327, 311, 336; 128/66.23; 600/437, 659, 447; 367/173, 367/174, 140, 162, 155
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,598,051 A * 1/1997 Frey 310/334
2004/0100163 A1* 5/2004 Baumgartner et al. 310/334

* cited by examiner

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(57) **ABSTRACT**

An ultrasonic probe, an ultrasonic imaging apparatus and a fabricating method thereof are provided. The ultrasonic probe includes a rear block, a flexible printed circuit board having wiring patterns formed thereon, a piezoelectric wafer, a ground electrode plate, an acoustic matching layer, an acoustic lens, and a plurality of slots. Holes are formed in at least one of the rear block, the piezoelectric wafer and the acoustic matching layer and wiring patterns are formed in the form of a matrix array, and thus vibration property and focusing can be improved to obtain clear images.

12 Claims, 14 Drawing Sheets

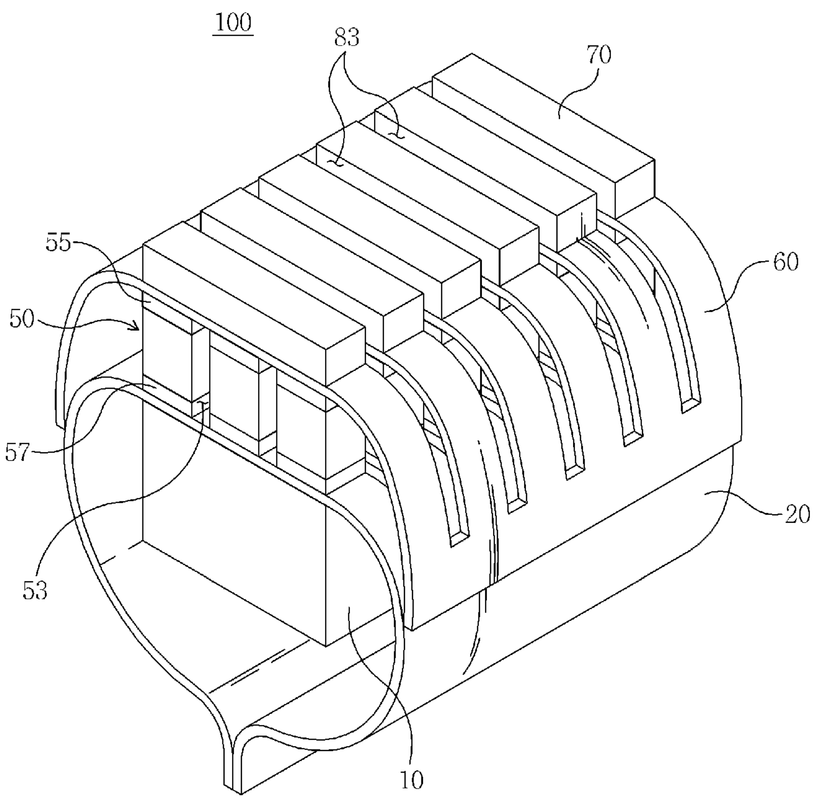


FIG. 1

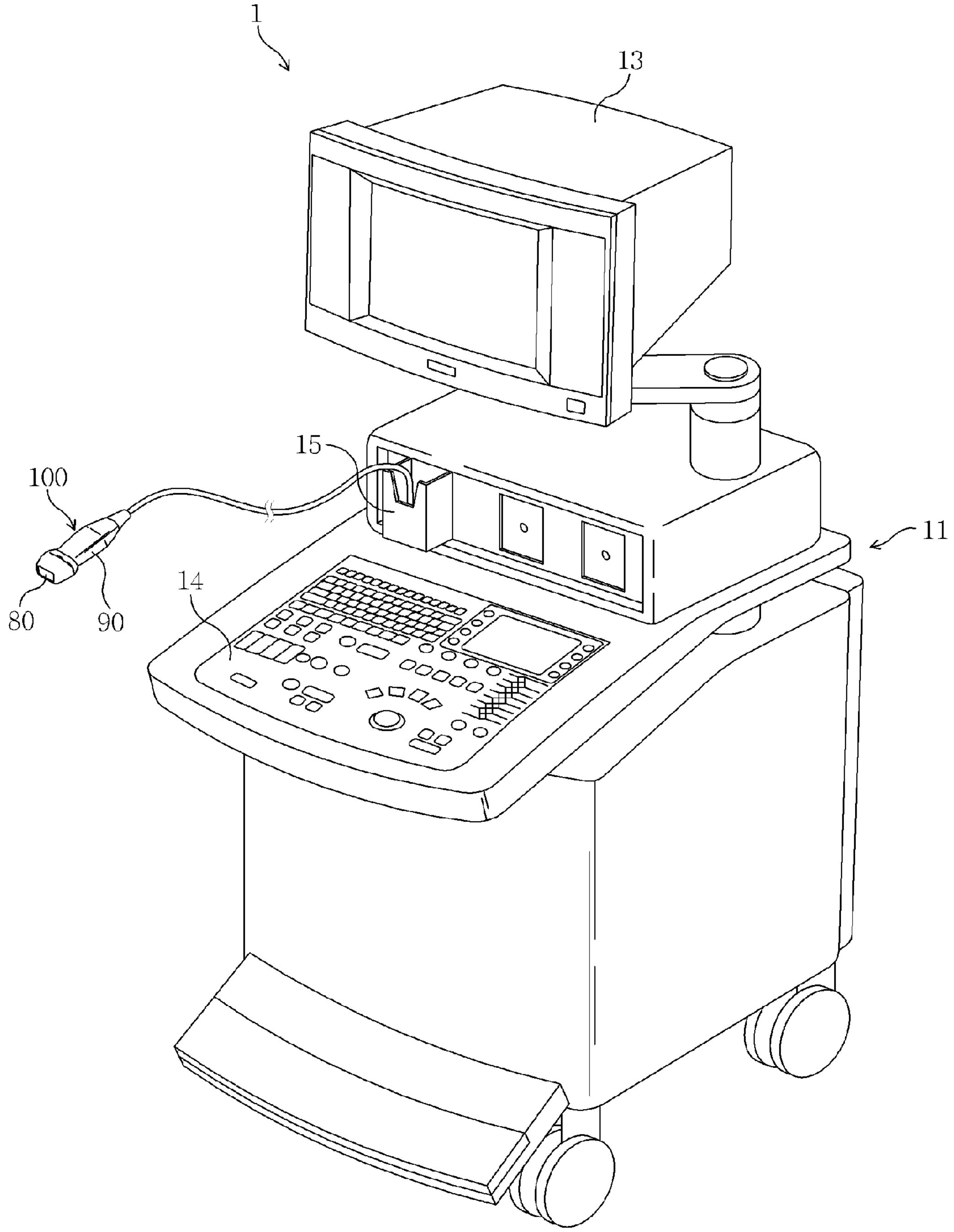


FIG. 2a

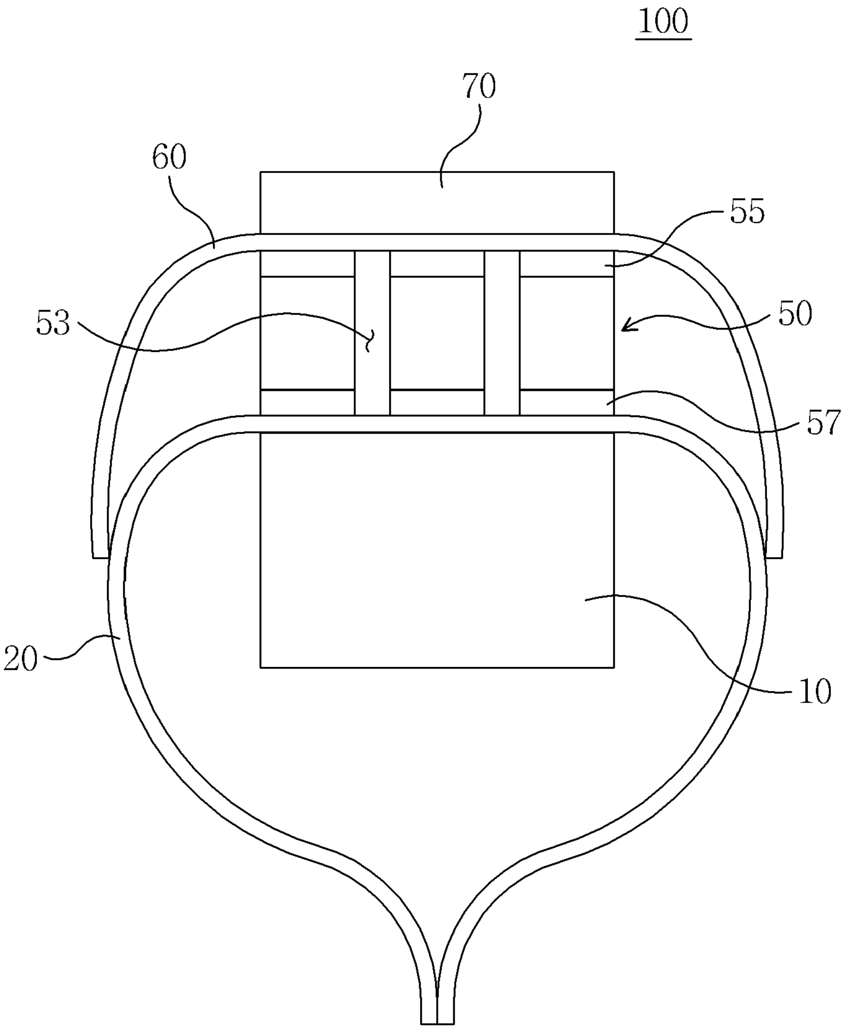


FIG. 2b

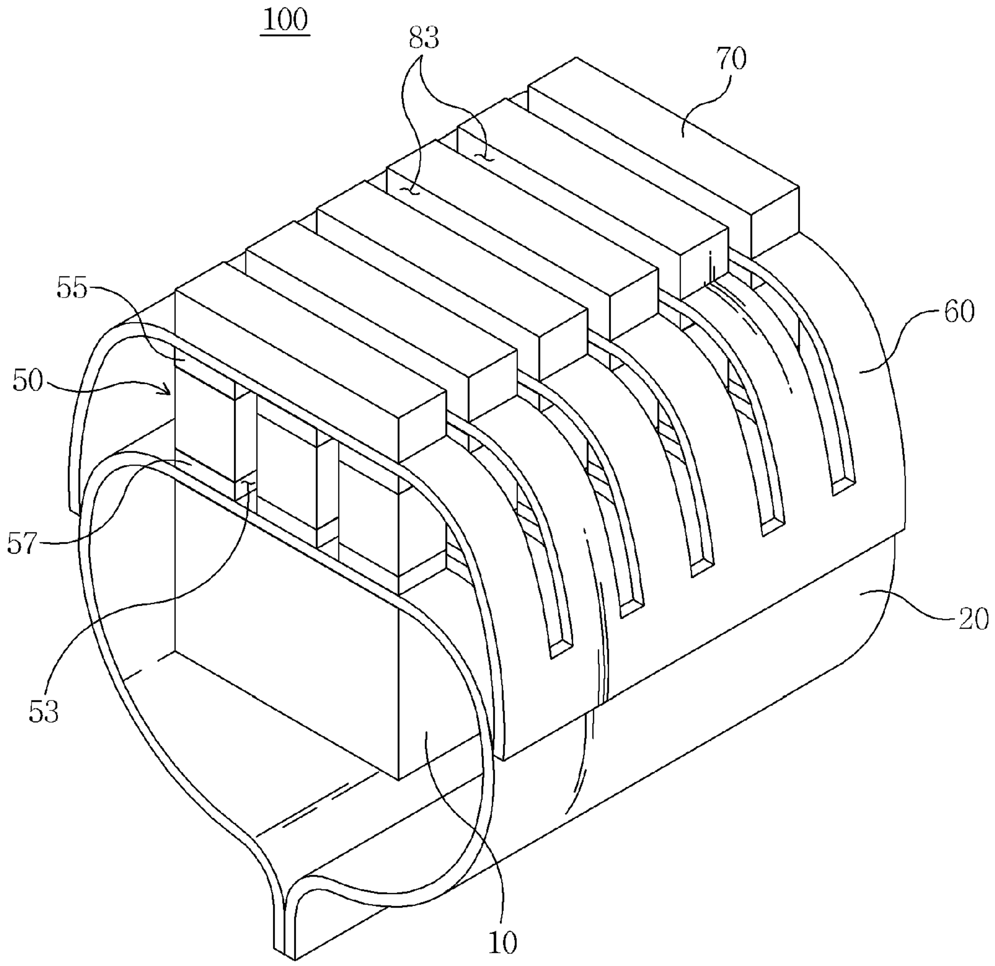


FIG. 3

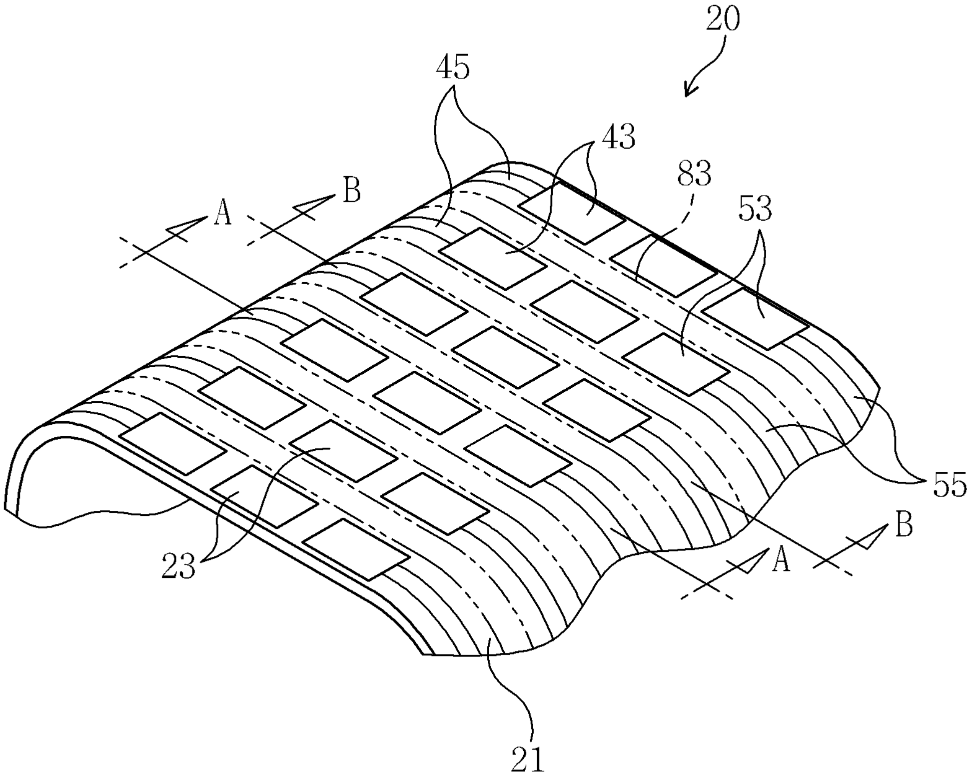


FIG. 4a

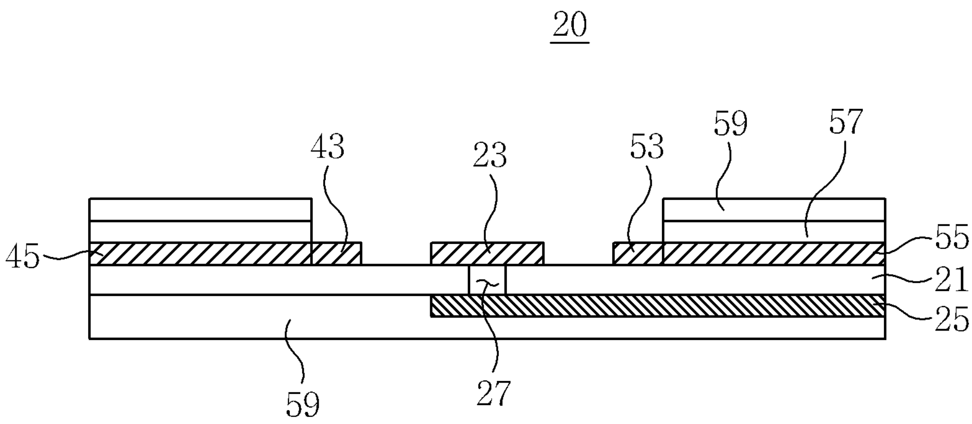


FIG. 4b

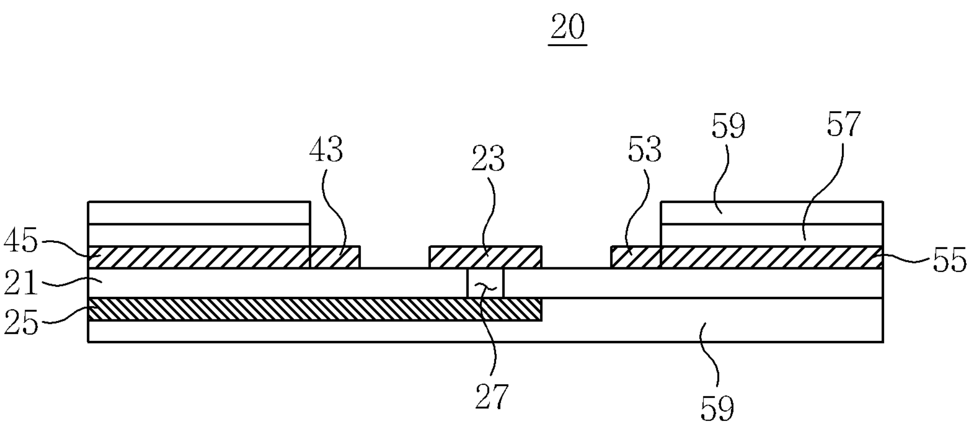


FIG. 5

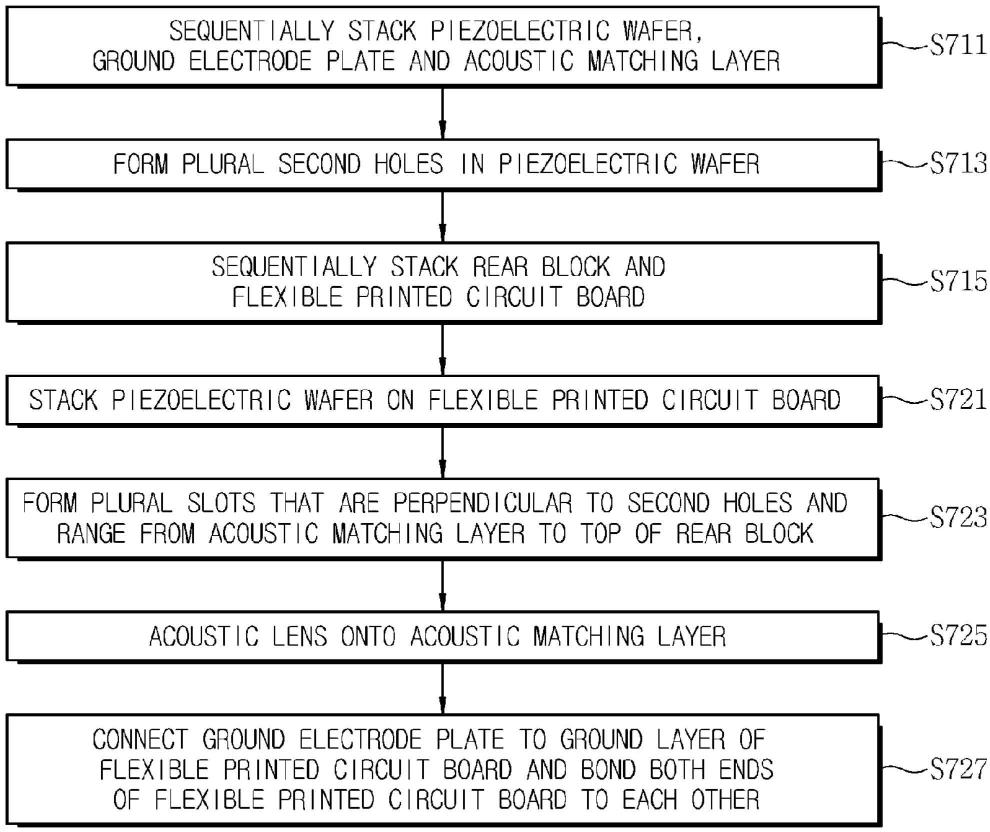

SEQUENTIALLY STACK PIEZOELECTRIC WAFER, GROUND ELECTRODE PLATE AND ACOUSTIC MATCHING LAYER
S711
FORM PLURAL SECOND HOLES IN PIEZOELECTRIC WAFER
S713
SEQUENTIALLY STACK REAR BLOCK AND FLEXIBLE PRINTED CIRCUIT BOARD
S715
STACK PIEZOELECTRIC WAFER ON FLEXIBLE PRINTED CIRCUIT BOARD
S721
FORM PLURAL SLOTS THAT ARE PERPENDICULAR TO SECOND HOLES AND RANGE FROM ACOUSTIC MATCHING LAYER TO TOP OF REAR BLOCK
S723
ACOUSTIC LENS ONTO ACOUSTIC MATCHING LAYER
S725
CONNECT GROUND ELECTRODE PLATE TO GROUND LAYER OF FLEXIBLE PRINTED CIRCUIT BOARD AND BOND BOTH ENDS OF FLEXIBLE PRINTED CIRCUIT BOARD TO EACH OTHER
S727

FIG. 6

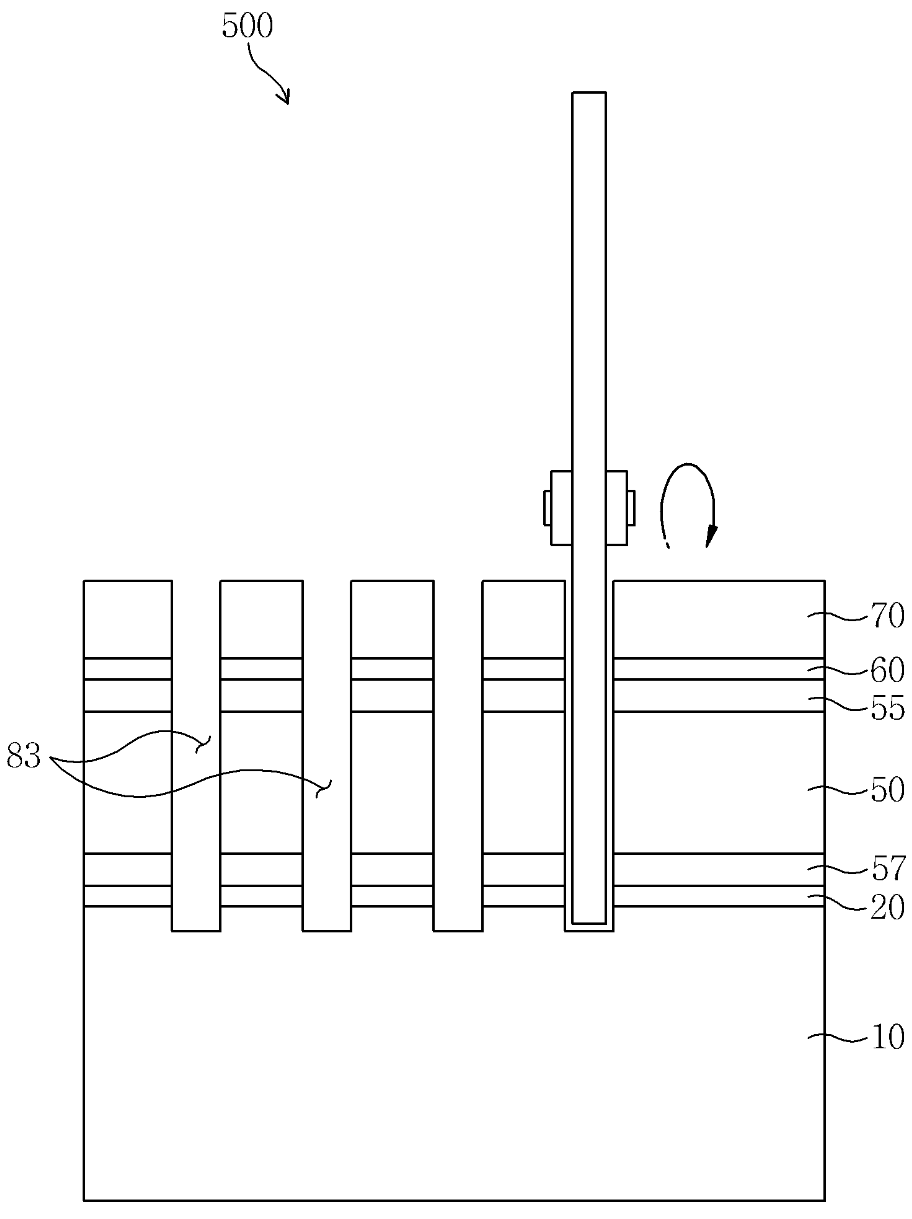


FIG. 7

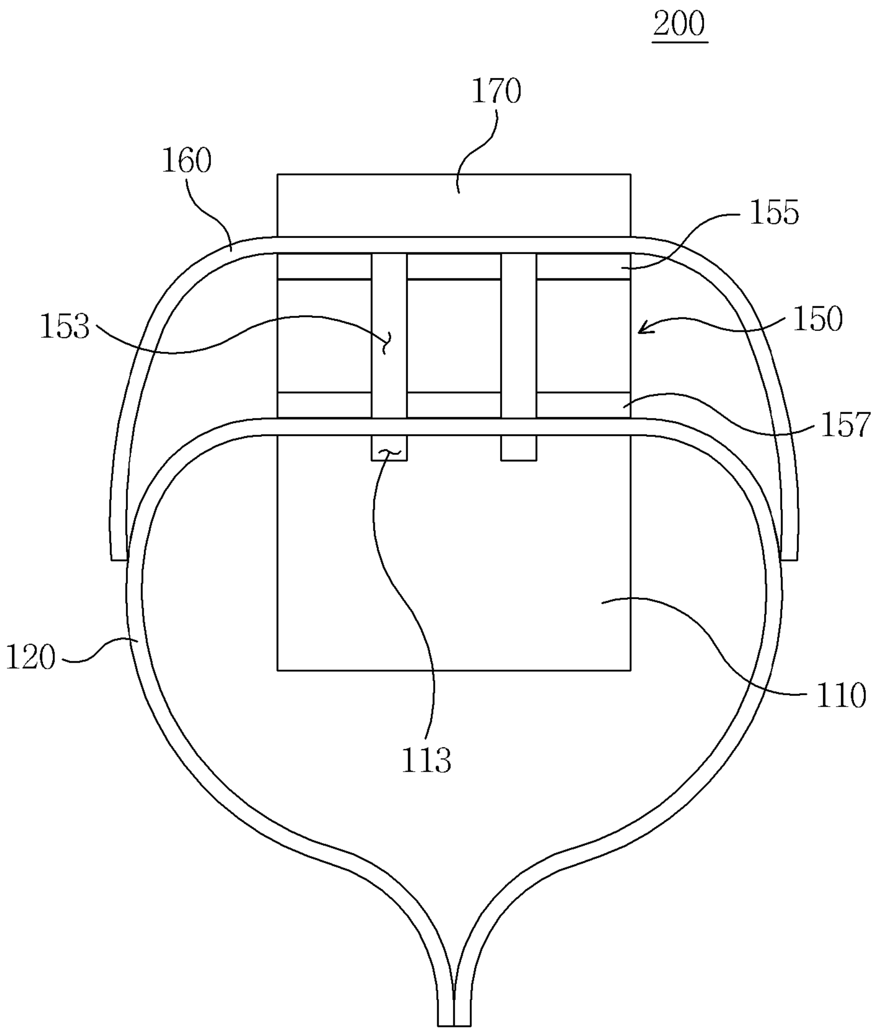


FIG. 8

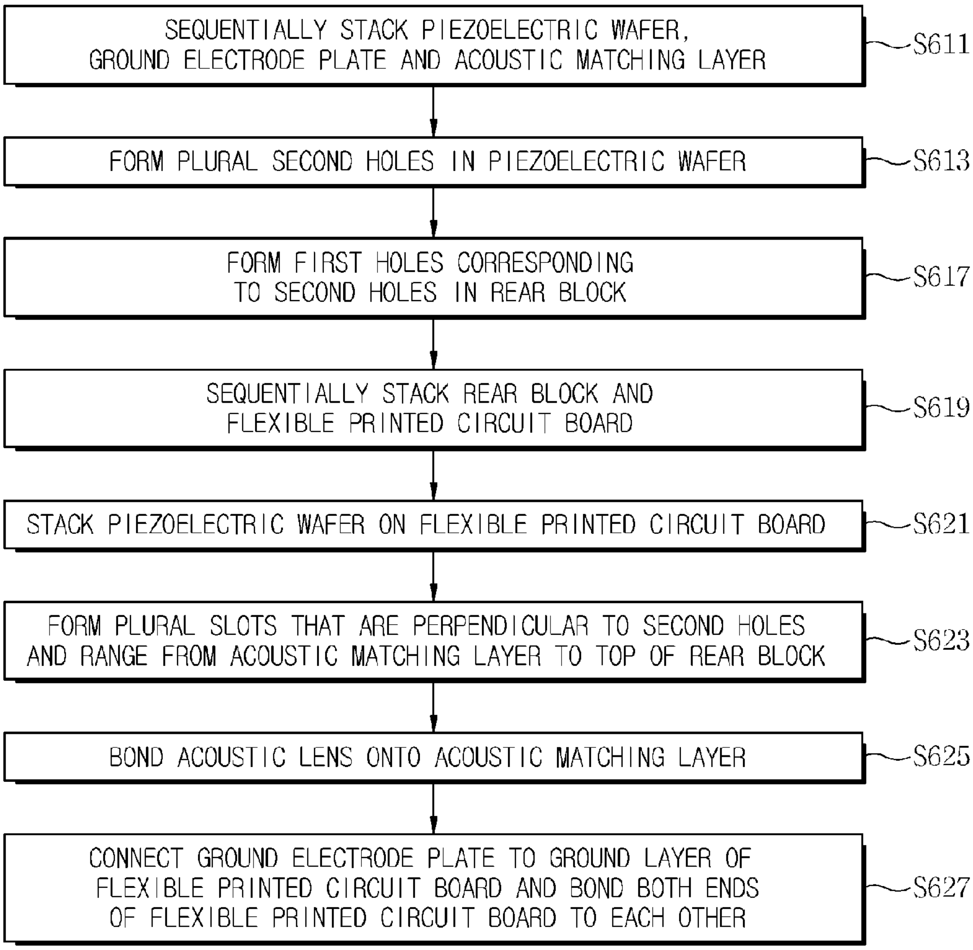

SEQUENTIALLY STACK PIEZOELECTRIC WAFER, GROUND ELECTRODE PLATE AND ACOUSTIC MATCHING LAYER
S611
FORM PLURAL SECOND HOLES IN PIEZOELECTRIC WAFER
S613
FORM FIRST HOLES CORRESPONDING TO SECOND HOLES IN REAR BLOCK
S617
SEQUENTIALLY STACK REAR BLOCK AND FLEXIBLE PRINTED CIRCUIT BOARD
S619
STACK PIEZOELECTRIC WAFER ON FLEXIBLE PRINTED CIRCUIT BOARD
S621
FORM PLURAL SLOTS THAT ARE PERPENDICULAR TO SECOND HOLES AND RANGE FROM ACOUSTIC MATCHING LAYER TO TOP OF REAR BLOCK
S623
BOND ACOUSTIC LENS ONTO ACOUSTIC MATCHING LAYER
S625
CONNECT GROUND ELECTRODE PLATE TO GROUND LAYER OF FLEXIBLE PRINTED CIRCUIT BOARD AND BOND BOTH ENDS OF FLEXIBLE PRINTED CIRCUIT BOARD TO EACH OTHER
S627

FIG. 9

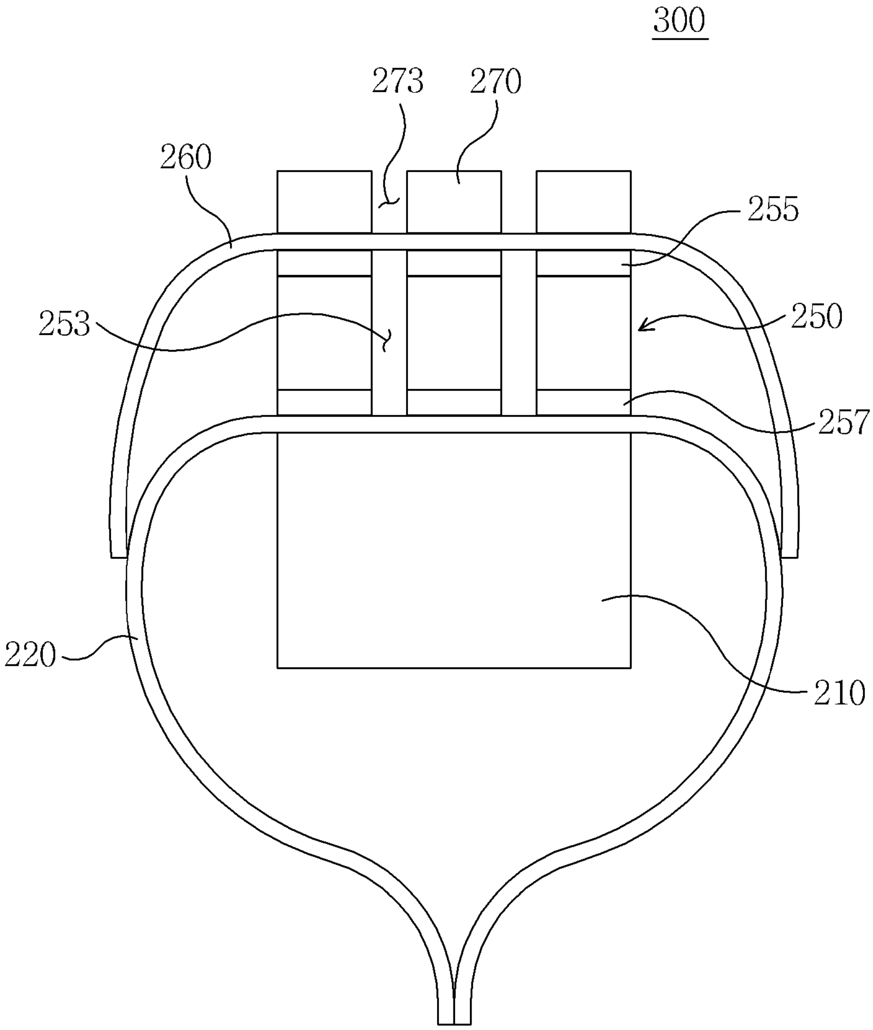


FIG. 10

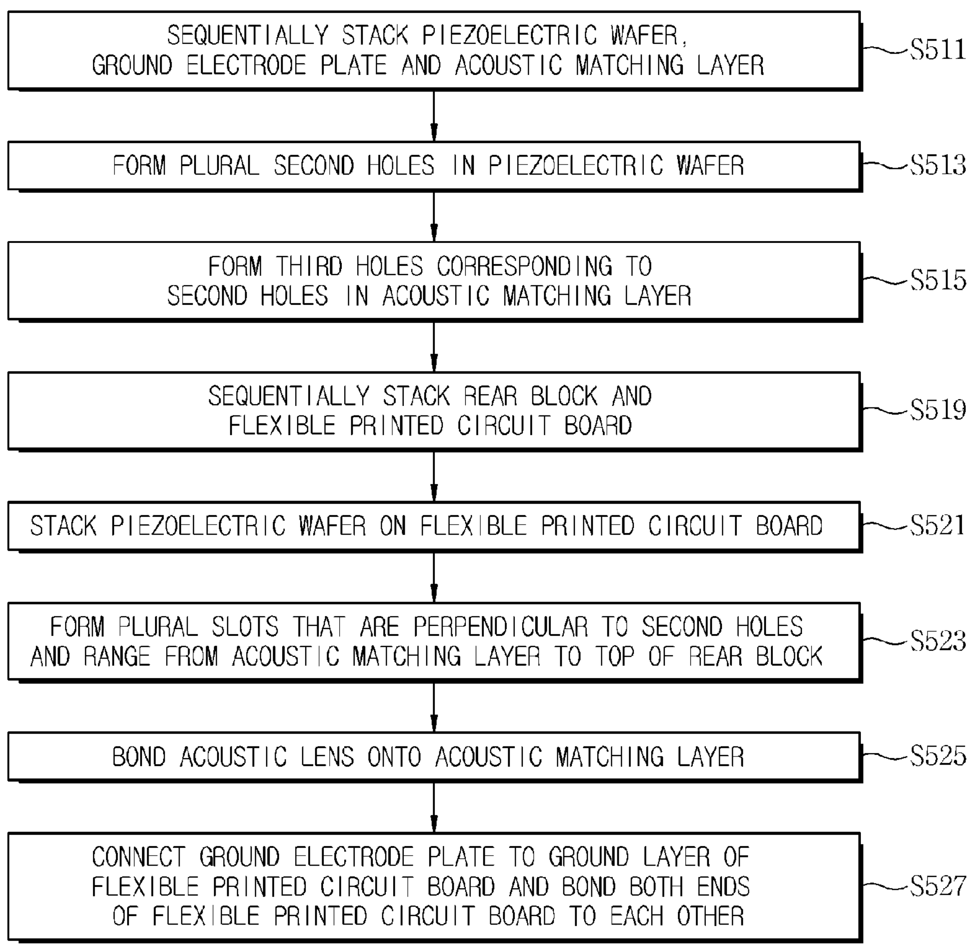

SEQUENTIALLY STACK PIEZOELECTRIC WAFER, GROUND ELECTRODE PLATE AND ACOUSTIC MATCHING LAYER
S511
FORM PLURAL SECOND HOLES IN PIEZOELECTRIC WAFER
S513
FORM THIRD HOLES CORRESPONDING TO SECOND HOLES IN ACOUSTIC MATCHING LAYER
S515
SEQUENTIALLY STACK REAR BLOCK AND FLEXIBLE PRINTED CIRCUIT BOARD
S519
STACK PIEZOELECTRIC WAFER ON FLEXIBLE PRINTED CIRCUIT BOARD
S521
FORM PLURAL SLOTS THAT ARE PERPENDICULAR TO SECOND HOLES AND RANGE FROM ACOUSTIC MATCHING LAYER TO TOP OF REAR BLOCK
S523
BOND ACOUSTIC LENS ONTO ACOUSTIC MATCHING LAYER
S525
CONNECT GROUND ELECTRODE PLATE TO GROUND LAYER OF FLEXIBLE PRINTED CIRCUIT BOARD AND BOND BOTH ENDS OF FLEXIBLE PRINTED CIRCUIT BOARD TO EACH OTHER
S527

FIG. 11a

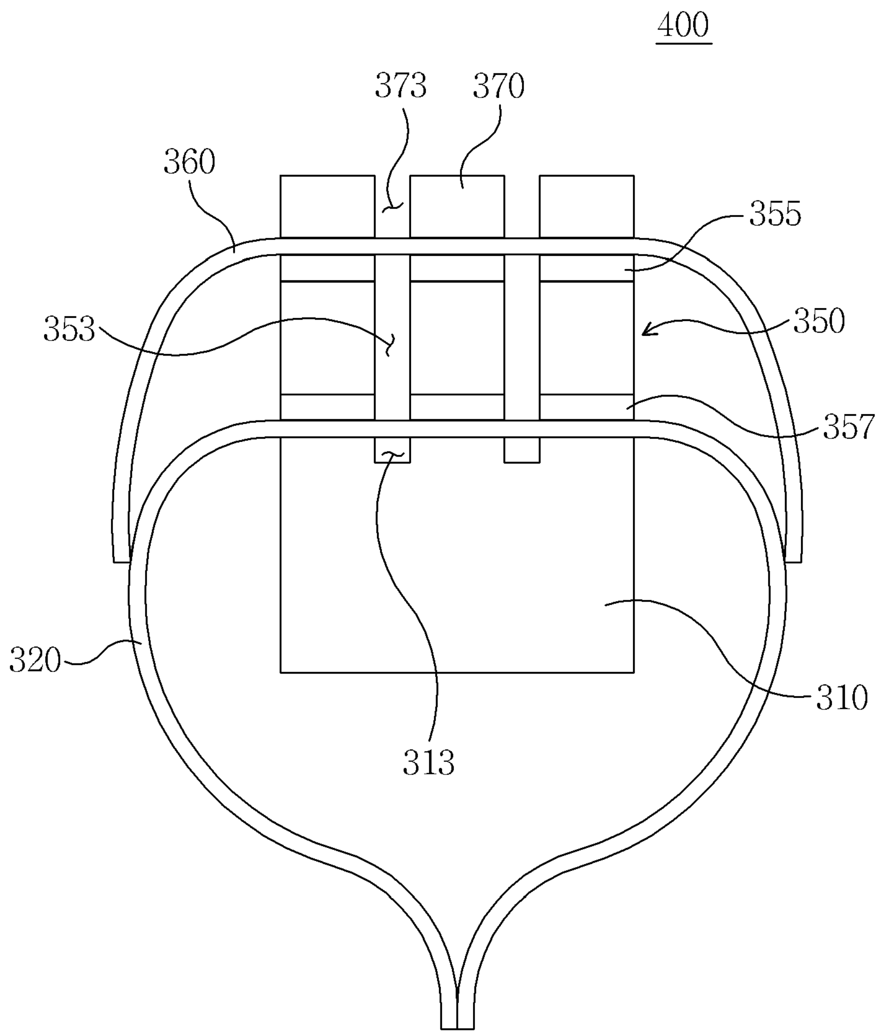


FIG. 11b

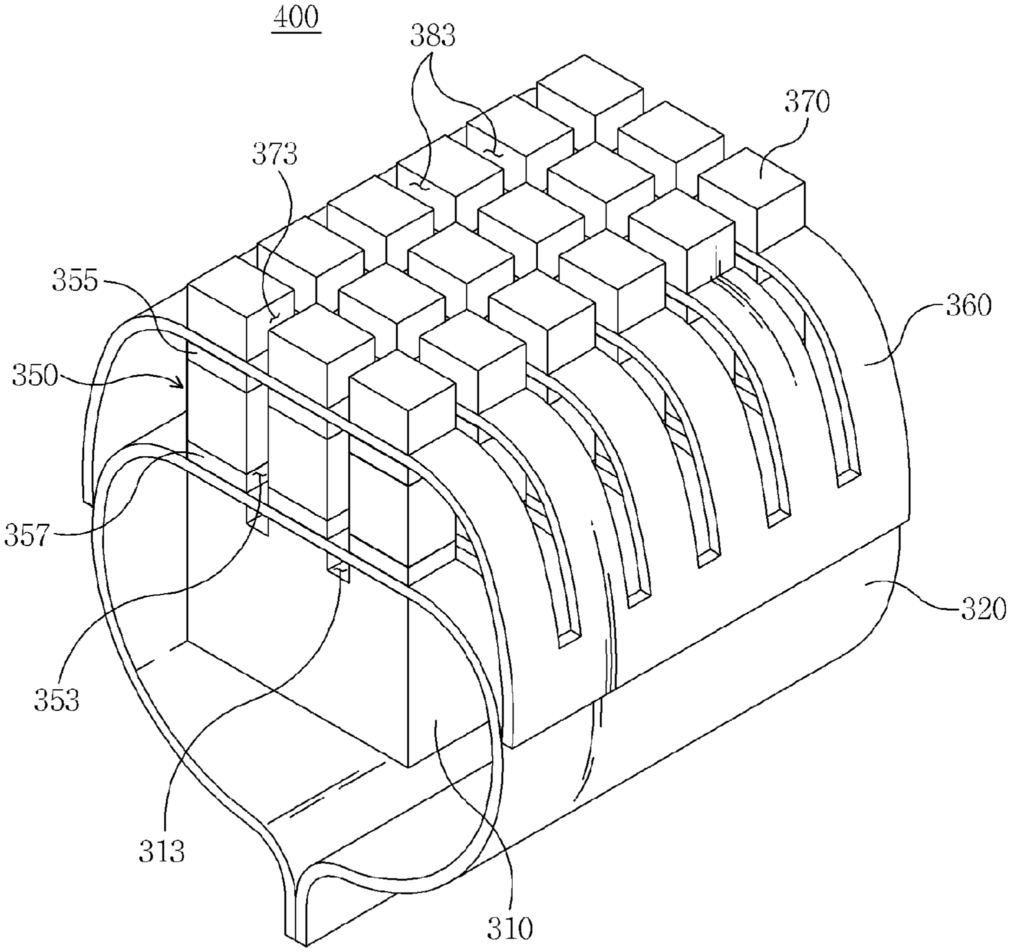
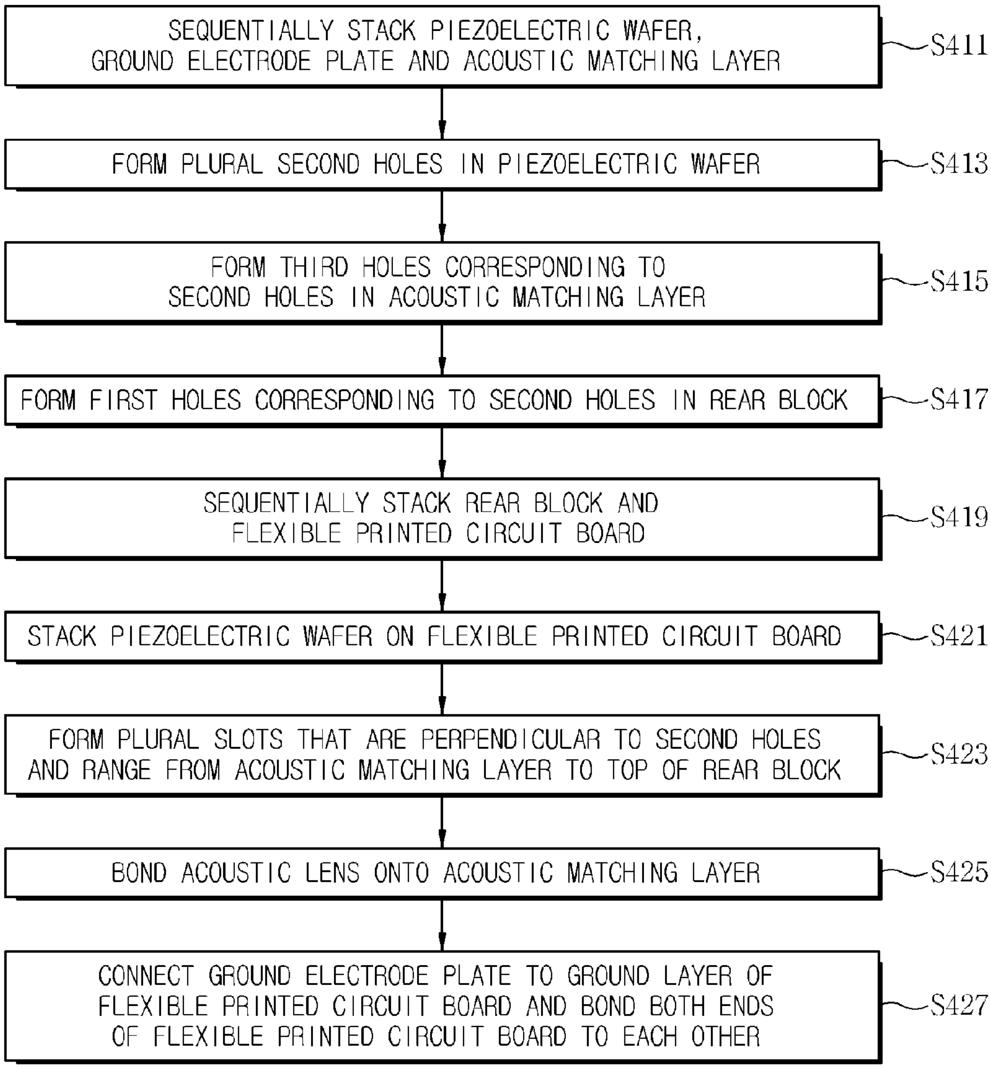


FIG. 12


SEQUENTIALLY STACK PIEZOELECTRIC WAFER, GROUND ELECTRODE PLATE AND ACOUSTIC MATCHING LAYER
S411
FORM PLURAL SECOND HOLES IN PIEZOELECTRIC WAFER
S413
FORM THIRD HOLES CORRESPONDING TO SECOND HOLES IN ACOUSTIC MATCHING LAYER
S415
FORM FIRST HOLES CORRESPONDING TO SECOND HOLES IN REAR BLOCK
S417
SEQUENTIALLY STACK REAR BLOCK AND FLEXIBLE PRINTED CIRCUIT BOARD
S419
STACK PIEZOELECTRIC WAFER ON FLEXIBLE PRINTED CIRCUIT BOARD
S421
FORM PLURAL SLOTS THAT ARE PERPENDICULAR TO SECOND HOLES AND RANGE FROM ACOUSTIC MATCHING LAYER TO TOP OF REAR BLOCK
S423
BOND ACOUSTIC LENS ONTO ACOUSTIC MATCHING LAYER
S425
CONNECT GROUND ELECTRODE PLATE TO GROUND LAYER OF FLEXIBLE PRINTED CIRCUIT BOARD AND BOND BOTH ENDS OF FLEXIBLE PRINTED CIRCUIT BOARD TO EACH OTHER
S427

ULTRASONIC PROBE, ULTRASONIC IMAGING APPARATUS AND FABRICATING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2009-0010661, filed on Feb. 10, 2009, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an ultrasonic probe, an ultrasonic imaging apparatus and a fabricating method thereof, and more particularly, to an ultrasonic probe, an ultrasonic imaging apparatus and a fabricating method thereof for enhancing vibration property and improving focusing of ultrasonic images to obtain clear images.

2. Description of the Related Art

Ultrasound is a method of examining tissues of the human body using ultrasonic waves, which irradiates ultrasonic waves to an affected area of the human body and detects an abnormal tissue through an image generated from a reflected signal. The ultrasound is used to diagnose lesions such as a tumor or test embryos.

Ultrasonic waves are defined as sound having a frequency higher than a frequency range that people can hear, generally, 20,000 Hz to 30 MHz. Ultrasonic waves for diagnosis of the human body are in the range of 1 MHz to 20 MHz.

An ultrasonic imaging apparatus used for ultrasound may be divided into three parts, that is, an ultrasonic probe, a signal processor and a display. The ultrasonic probe converts electric and ultrasonic signals and the signal processor processes receiving signals and transmitting signals. The display generates images using signals obtained from the ultrasonic probe and the signal processor. Particularly, the ultrasonic probe is an important part that determines the quality of an ultrasonic image.

The ultrasonic probe includes a piezoelectric wafer, an electrode, an acoustic matching layer, a printed circuit board and an acoustic lens, in general. The size of the ultrasonic probe is decreasing, which requires a method of arranging wiring patterns for processing ultrasonic and electric signals in the ultrasonic probe and a technique for improving vibration property and focusing to obtain clear ultrasonic images and widen a signal bandwidth.

SUMMARY OF THE INVENTION

The present invention provides an ultrasonic probe, an ultrasonic imaging apparatus and a fabricating method thereof for enhancing the vibration property of the ultrasonic imaging apparatus an improving focusing of ultrasonic images to obtain clear images.

According to an aspect of the present invention, there is provided an ultrasonic probe including a rear block having a predetermined thickness, a flexible printed circuit board stacked on the rear block to surround the top face and side of the rear block and having wiring patterns formed thereon, a-piezoelectric wafer stacked on the top face of the flexible printed circuit board and having upper and lower electrodes respectively formed on both sides thereof and a plurality of first vertical holes formed therein, a ground electrode plate stacked on the top face of the piezoelectric wafer, bonded to the upper electrode and connected to a ground layer of the flexible printed circuit board, an acoustic matching layer stacked on the top face of the ground electrode plate, an acoustic lens bonded onto the acoustic matching layer, and a plurality of slots formed in the direction perpendicular to the first vertical holes and ranging from in the acoustic matching layer to the top of the rear block.

The flexible printed circuit board includes a base film formed of an insulating material and having a bottom face bonded onto the rear block and a top face opposite to the bottom face, and wiring patterns formed on both sides of the base film. The wiring patterns includes a central wiring pattern that is formed on the top face of the base film, has a central pad formed between neighboring first vertical holes, is connected to the central pad through a via and is extended to the outside of the rear block through the bottom face of the base film, a first wiring pattern that has a first pad formed at one side of the central pad, is connected to the first pad and is arranged at one side of the top face of the base film, a second wiring pattern that has second pad formed on the other side of the central pad, is connected to the second pad and is arranged at the other side of the top face of the base film, a protective layer formed on the bottom face of the central wiring pattern and the top faces of the first and second wiring patterns to protect the central wiring pattern, the first and second wiring patterns, and a ground layer formed on the protective layer formed on the top faces of the first and second wiring patterns and connected to the ground electrode plate.

According to another aspect of the present invention, there is provided an ultrasonic imaging apparatus includes the ultrasonic probe and a main body having a connector connected to the ultrasonic probe.

According to another aspect of the present invention, there is provided a method of fabricating an ultrasonic probe, which includes a first stacking step of sequentially stacking a piezoelectric wafer, a ground electrode plate and an acoustic matching layer, a second hole forming step of forming a plurality of first vertical holes in the piezoelectric wafer, a second stacking step of sequentially stacking a rear block and a flexible printed circuit board, a third stacking step of stacking the piezoelectric wafer on the flexible printed circuit board, a slot forming step of forming a plurality of slots perpendicular to the first vertical holes such that the slots range from the acoustic matching layer to the top of the rear block, and a bonding step of bonding an acoustic lens onto the acoustic matching layer.

According to the present invention, holes are formed in at least one of the rear block, the piezoelectric wafer and the acoustic matching layer and a plurality of slots are formed through a one-time dicing process such that the slots range from the acoustic matching layer to the top of the rear block to form a wiring patterns in the form of a matrix array. Accordingly, the vibration property and focusing can be improved to obtain clear images.

Furthermore, the present invention reduces ultrasonic signal interference and provides a wide bandwidth and high sensitivity.

Moreover, a wiring pattern is arranged in the form of a matrix array to control ultrasonic signals or power used for ultrasound, and thus it is possible to adjust a focusing depth, extend an ultrasound area and obtain clear images.

In addition, the connector that connects the ultrasonic probe to the main body of the ultrasonic imaging apparatus is located on the top of the main body, and thus users can use the ultrasonic imaging apparatus conveniently.

Additional aspects and/or advantages of the invention 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 invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. **1** illustrates an ultrasonic imaging apparatus according to a first embodiment of the present invention;

FIG. **2**A is a cross-sectional view of an ultrasonic probe according to the first embodiment of the present invention;

FIG. **2**B: is a perspective view of the ultrasonic probe according to the first embodiment of the present invention;

FIG. **3** is a perspective view of a flexible printed circuit board according to an embodiment of the present invention;

FIG. **4**A is a cross-sectional view taken along line A-A of FIG. **3**;

FIG. **4**B is a cross-sectional view taken along line B-B of FIG. **3**;

FIG. **5** is a flowchart showing a method of fabricating the ultrasonic probe according to the first embodiment of the present invention;

FIG. **6** illustrates a method of forming slots of the ultrasonic probe according to the first embodiment of the present invention;

FIG. **7** is a cross-sectional view of an ultrasonic probe according to a second embodiment of the present invention;

FIG. **8** is a flowchart showing a method of fabricating the ultrasonic probe according to the second embodiment of the present invention;

FIG. **9** is a cross-sectional view of an ultrasonic probe according to a third embodiment of the present invention;

FIG. **10** is a flowchart showing a method of fabricating the ultrasonic probe according to the third embodiment of the present invention;

FIG. **11**A is a cross-sectional view of an ultrasonic probe according to a fourth embodiment of the present invention;

FIG. **11**B is a perspective view of the ultrasonic probe according to the fourth embodiment of the present invention; and

FIG. **12** is a flowchart showing a method of fabricating the ultrasonic probe according to the fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention will now be described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art. Throughout the drawings, like reference numerals refer to like elements.

FIG. **1** shows an ultrasonic imaging apparatus **10** according to a first embodiment of the present invention. Referring to FIG. **1**, the ultrasonic imaging apparatus **1** includes a main body **11**, an ultrasonic probe **100**, a display **13** and an input unit **14**.

The main body **11** includes a signal processor that transmits and receives electric and ultrasonic signals and a storage unit that stores application programs and data required for ultrasound. Further, a connector **15** for connecting the ultrasonic probe **100** to the main body **11** is provided outside the main body **11**. The connector **15** is placed on the top of the main body **11** such that a user can easily connect the ultrasonic probe **100** to the main body **11**.

The ultrasonic probe **100** includes an acoustic lens **80** coming into contact with an affected area of a patient and a case **90** covering the other components of the ultrasonic probe **100**. The acoustic lens **80** is used for focusing an ultrasonic image and arranged to cover an acoustic matching layer placed under the acoustic lens **80**. The acoustic lens **80** may be made of silicon. The other components of the ultrasonic probe **100**, covered with the case **90**, will be explained in detail later.

The display **13** displays ultrasonic images obtained through application programs executed for ultrasound and examination.

The input unit **14** is used to execute the application programs or input data required for examination and includes a plurality of keys.

The ultrasonic probe **100** according to the first embodiment of the present invention will now be explained with reference to FIGS. **2**A and **2**B. FIG. **2**A is a cross-sectional view of the ultrasonic probe **100** according to the first embodiment of the present invention and FIG. **2**B is a perspective view of the ultrasonic probe **100** according to the first embodiment of the present invention.

The ultrasonic probe **100** according to the first embodiment of the present invention includes a rear block **10**, a flexible printed circuit board **20**, a piezoelectric wafer **50**, a ground electrode plate **60** and an acoustic matching layer **70**, which are sequentially stacked. While the ultrasonic probe **100** according to the first embodiment of the present invention includes the acoustic lens **80** (shown in FIG. **1**) placed on the acoustic matching layer **70**, the acoustic lens is not shown in FIGS. **2**A and **2**B.

The rear block **10** is located at the bottom of the ultrasonic probe **100** and absorbs unnecessary ultrasonic signals traveling to the rear block **10** from the piezoelectric wafer **50**.

The flexible printed circuit board **20** is located on the top face of the rear block **10** and has wiring patterns formed on both sides thereof. The flexible printed circuit board **20** will be explained in more detail later.

The piezoelectric wafer **50** is arranged on the top face of the flexible printed circuit board **20** and has upper and lower electrodes **55** and **57** respectively formed on both sides thereof and a plurality of first vertical holes **53**.

While two first vertical holes **53** are formed in the piezoelectric wafer **50** in the first embodiment of the present invention, the number of first vertical holes is not limited thereto. The piezoelectric wafer **50** may be formed of PZT or PMN-PT. The upper and lower electrodes **55** and **57** are formed through sputtering, electron beam, thermal evaporation or electroplating. The upper electrode **55** is connected to the ground electrode plate **60** and the lower electrode **57** is connected to the flexible printed circuit board **20**.

The ground electrode plate **60** has a metal layer formed on the top face thereof and an insulating layer formed on the bottom face thereof and surrounds the top face and the side of the piezoelectric wafer **50**. The flexible printed circuit board **20** includes a ground layer. The bottom end of the ground electrode plate **60** is connected to the ground layer of the flexible printed circuit board **20**.

The acoustic matching layer **70** is made of metal powder or ceramic powder and formed on the top face of the ground electrode plate **60**.

A plurality of slots **83** are formed such that the plurality of slots **83** range from the acoustic matching-layer **70** to the top of the rear block **10** in the direction perpendicular to the first vertical holes **53**. While the ultrasonic probe **100** according to the first embodiment of the present invention has five slots **83**, the number of slots **83** is not limited thereto.

The acoustic lens (not shown) is used for focusing ultrasonic images and located on the top face of the acoustic matching layer **70**.

The flexible printed circuit board **20** and the wiring patterns according to the first embodiment of the present invention will now be explained with reference to FIGS. 2A, 2B, **3**, **4**A and **4**B. FIG. **3** is a perspective view of the flexible printed circuit **20**, FIG. **4**A is a cross-sectional view taken along line A-A of FIG. **3** and FIG. **4**B is a cross-sectional view taken along line B-B of FIG. **3**.

FIG. **3** shows the flexible printed circuit board **20** before the slots **83** are formed. Positions of the slots **83** are indicated by dotted lines in FIG. **3**.

The flexible printed circuit board **20** includes a base film **31** and wiring patterns. The base film **31** is made of an insulating material. The bottom face of the base film **31** is bonded to the top face of the rear block **10** and the top face thereof is opposite to the bottom face. The wiring patterns are divided into a central wiring pattern **33**, a first wiring pattern **35** and a second wiring pattern **37** and formed on both sides of the base film **31**.

The central wiring pattern **33** is formed on the top face of the base film **31** and includes a central pad **43** formed in the region between neighboring first vertical holes **53**. The central wiring pattern **33** is connected to the central pad **43** through a via **39** and extended to the outside of the rear block **10** through the bottom face of the base film **31**. Here, the central wiring pattern **33** is alternately arranged on one side and the other side of the central pad **43**. Accordingly, the central wiring pattern **33** shown in FIG. **4**A is located at the right side of the central pad **43** while the central wiring pattern **33** shown in FIG. **4**B is formed at the left side of the central pad **43**.

The first wiring pattern **35** includes a first pad **45** formed at one side of the central pad **43**, is connected to the first pad **45** and arranged at one side of the top face of the base film **31**. The second wiring pad **37** includes a second pad **47** formed at the other side of the central pad **43**, is connected to the second pad **47** and arranged at the other side of the top face of the base film **31**.

A protective layer **41** for protecting the wiring patterns is formed on the bottom face of the central wiring pattern **33** and the top faces of the first and second wiring patterns **35** and **37**. Here, the central pad **43**, the first pad **45** and the second pad **47** are not protected by the protective layer **41** and they are exposed to be connected to the lower electrode **57** of the piezoelectric wafer **50**.

A ground layer **49** is formed on the protective layer **41** formed on the first and second wiring patterns **35** and **37** and connected to the ground electrode plate **60**.

While the central pad **43**, the first pad **45** and the second pad **47** form a 3.times.6 matrix array in the flexible printed circuit board **20** according to the first embodiment of the present invention, they can form 3.times.64 through 3.times.192 matrix arrays.

Furthermore, while the flexible printed circuit board **20** according to the first embodiment of the present invention has the three wiring patterns including the central wiring pattern **33**, the first wiring pattern **35** and the second wiring pattern **37**, the number of wiring patterns is not limited thereto. If five wiring patterns are formed, the central wiring pattern is alternately formed on one side and the other side of the bottom face of the base film, two wiring patterns are formed on one side of the central wiring pattern and the other two wiring patterns are formed on the other side of the central wiring pattern. The two wiring patterns are respectively arranged at both ends of the flexible printed circuit board.

In general, circuit connection is achieved at a contact portion of the piezoelectric wafer **50** and the flexible printed circuit board **20**. A 1.5D (Dimension) ultrasonic probe has a multi-level circuit structure in order to connect circuits on both ends of the ultrasonic probe. However, the vibration and acoustic properties of the ultrasonic probe **100** increases as the thicknesses of the rear block **10**, the piezoelectric wafer **50** and the acoustic matching layer **70**, the flexible printed circuit **20** and the ground electrode plate **60** decreases. Accordingly, circuits on both sides of the flexible printed circuit board **20** according to the present invention are not connected at the contact portion of the flexible printed circuit board **20** and the piezoelectric wafer **50** and both ends of the flexible printed circuit board **20** are bonded to each other, as shown in FIG. 2B, and thus the thickness of the flexible printed circuit board **20** coming into contact with the piezoelectric wafer **50** decreases to improve the acoustic property of the ultrasonic probe **100**.

A method of fabricating the ultrasonic probe according to the first embodiment of the present invention will now be explained with reference to FIGS. **2** through **6**. FIG. **5** is a flowchart showing the method of fabricating the ultrasonic probe according to the first embodiment of the present invention and FIG. **6** illustrates a method of forming the slots of the ultrasonic probe according to the first embodiment of the present invention.

Referring to FIG. **5**, the piezoelectric wafer **50**, the ground electrode plate **60** and the acoustic matching layer **70** are sequentially stacked in step **S711**.

The plurality of first vertical holes **53** are formed in the piezoelectric wafer **50** in step **S713**.

The rear block **10** and the flexible printed circuit board **20** are sequentially stacked in step **S715**.

The piezoelectric wafer **50**, stacked in step **S711**, is located on the top face of the flexible printed circuit board **20**, stacked in step **S715**, in step **S721**.

When the rear block **10**, the flexible printed circuit board **20**, the piezoelectric wafer **50**, the ground electrode plate **60** and the acoustic matching layer **70** are sequentially stacked, the plurality of slots **83** are formed such that the plurality of slots **83** range from the acoustic matching layer **70** to the top of the rear block **10** in the direction perpendicular to the first vertical holes **53** in step **S723**.

The acoustic lens (not shown) is bonded onto the acoustic matching layer **70** having the slots **83** formed therein to cover the overall surface of the acoustic matching layer **70** in step **S725**. The acoustic lens is formed of a material such as silicon and bonded onto the acoustic matching layer **70** using a silicon primer.

The ground electrode plate **60** is connected to the ground layer **59** of the flexible printed circuit board **20** and both ends of the flexible printed circuit board **20** are bonded to each other to connect the first and second wiring patterns **45** and **55** to construct a circuit in step **S727**.

The method of forming the slots **83** in step **S723** will now be explained with reference to FIG. **6**.

Referring to FIG. **6**, the slots **83** are formed in the rear block **10**, the flexible printed circuit board **20**, the piezoelectric wafer **50**, the ground electrode plate **60** and the acoustic matching layer **70**, stacked in step **3723**, using a dicing machine **500**. FIG. **6** shows that four of five slots **83** are formed.

The dicing machine **500** used in step S**723** can be used to form the first vertical holes **53** in the piezoelectric wafer **50**.

The ultrasonic probe according to the present invention is bonded using general epoxy in the stacking and bonding steps because electrical bonding can be achieved by coating the general epoxy thin by 1 to 2.mu.m. While the general epoxy substitutes for a conductive epoxy having relatively weak adhesiveness, the adhesive used to bond the ultrasonic probe is not limited to the general epoxy.

An ultrasonic probe **200** according to a second embodiment of the present invention will now be explained with reference to FIGS. **7** and **8**. FIG. **7** is a cross-sectional view of the ultrasonic probe **200** according to the second embodiment of the present invention and FIG. **8** is a flowchart showing a method of fabricating the ultrasonic probe **200** according to the second embodiment of the present invention.

The ultrasonic probe **200** according to the second embodiment of the present invention includes a plurality of second vertical holes **113** formed in a rear block **110** and a plurality of first vertical holes **153** formed in a piezoelectric wafer **150**. The number of second vertical holes **113** equals the number of first vertical holes **113** and the second vertical and first vertical holes **113** and **153** have the same size. The ultrasonic probe **200** according to the second embodiment of the present invention can reduce ultrasonic interference and improve vibration property according to the second vertical holes **113** formed in the rear block **110**.

Referring to FIGS. **7** and **8**, the piezoelectric wafer **150**, a ground electrode plate **160** and an acoustic matching layer **170** are sequentially stacked in step S**611**. The plurality of first vertical holes **153** are formed in the piezoelectric wafer **150** in step S**613** and the second vertical holes **113** corresponding to the first vertical holes **153** are formed in the rear block **110** in step S**617**.

The rear block **110** having the second vertical holes **113** formed therein and a flexible printed circuit board **120** are sequentially stacked in step S**619**. Here, it is more desirable to form the second vertical holes **113** in the rear block **110** and then stack the flexible printed circuit board **120** on the rear block **110**.

The piezoelectric wafer **150**, arranged in step S**611**, is stacked on the flexible printed circuit board **120**, placed on the rear block **110** in step S**619**, in step S**621**.

A plurality of slots (not shown) perpendicular to the first vertical holes **153** are formed such that the slots range from the acoustic matching layer **170** to the top of the rear block **110** in step S**623**.

An acoustic lens (not shown) is bonded onto the acoustic matching layer **170** having the slots formed therein to cover the overall surface of the acoustic matching layer **170** in step S**625**.

The ground electrode plate **160** is connected to a ground layer (not shown) of the flexible printed circuit board **120** and both ends of the flexible printed circuit board **120** are bonded to each other to connect first and second wiring patterns (not shown) to thereby construct a circuit in step S**627**.

An ultrasonic probe **200** according to a third embodiment of the present invention will now be explained with reference to FIGS. **9** and **10**. FIG. **9** is a cross-sectional view of the ultrasonic probe **300** according to the third embodiment of the present invention and FIG. **10** is a flowchart showing a method of fabricating the ultrasonic probe **300** according to the third embodiment of the present invention.

The ultrasonic probe **300** according to the third embodiment of the present invention includes a plurality of first vertical holes **253** formed in a piezoelectric wafer **250** and a plurality of third vertical holes **273** formed in an acoustic matching layer **270**. Here, the number of first vertical holes **273** equals the number of third vertical holes **273** and the first vertical and third vertical holes **253** and **273** have the same size. The ultrasonic probe **300** according to the third embodiment of the present invention reduces ultrasonic interference according to the third vertical holes **273** formed in the acoustic matching layer **270** to improve vibration property.

Referring to FIGS. **9** and **10**, the piezoelectric wafer **250**, a ground electrode plate **260** and an acoustic matching layer **270** are sequentially stacked in step S**511**. The plurality of first vertical holes **253** are formed in the piezoelectric wafer **250** in step S**513** and the third vertical holes **273** corresponding to the first vertical holes **253** are formed in the acoustic matching layer **270** in step S**515**.

A rear block **210** and a flexible printed circuit board **220** are sequentially stacked in step S**519**.

The piezoelectric wafer **250**, arranged in step S**511**, is stacked on the flexible printed circuit board **220**, placed on the rear block **210** in step S**519**, in step S**521**.

A plurality of slots (not shown) perpendicular to the first vertical holes **253** are formed such that the slots range from the acoustic matching layer **270** to the top of the rear block **210** in step S**523**.

An acoustic lens (not shown) is bonded onto the acoustic matching layer **270** having the slots formed therein to cover the overall surface of the acoustic matching layer **270** in step S**525**.

The ground electrode plate **260** is connected to a ground layer (not shown) of the flexible printed circuit board **220** and both ends of the flexible printed circuit board **220** are bonded to each other to connect first and second wiring patterns (not shown) to thereby construct a circuit in step S**527**.

An ultrasonic probe **400** according to a fourth embodiment of the present invention will now be explained with reference to FIGS. **11**A, **11**B and **12**. FIG. **11**A is a cross-sectional view of the ultrasonic probe **400** according to the fourth embodiment of the present invention, FIG. **11**B is a perspective view of the ultrasonic probe **400** according to the fourth embodiment of the present invention and FIG. **12** is a flowchart showing a method of fabricating the ultrasonic probe **400** according to the fourth embodiment of the present invention.

The ultrasonic probe **400** according to the fourth embodiment of the present invention includes a plurality of second vertical holes **313** formed in a rear block **310**, a plurality of first vertical holes **353** formed in a piezoelectric wafer **350** and a plurality of third vertical holes **373** formed in an acoustic matching layer **370**. The number of second vertical holes **313**, the number of first vertical holes **353** and the number of third vertical holes **373** are identical and the first, first vertical and third vertical holes **313**, **353** and **373** have the same size. The ultrasonic probe **400** according to the fourth embodiment of the present invention can minimize inter-layer interference according to the first, first vertical and third vertical holes **313**, **353** and **373** formed in the rear block **310**, the piezoelectric wafer **350** and the acoustic matching layer **370** to improve vibration property.

Referring to FIGS. **11**A, **11**B and **12**, the piezoelectric wafer **350**, a ground electrode plate **360** and the acoustic matching layer **370** are sequentially stacked in step S**411**. The plurality of first vertical holes **353** are formed in the piezoelectric wafer **350** in step S**413** and the third vertical holes **373** corresponding to the first vertical holes **353** are formed in the acoustic matching layer **370** in step S**415**. The second vertical holes **313** corresponding to the first vertical and third vertical holes **353** and **373** are formed in the upper part of the rear block **310** in step S**417**.

The rear block **310** having the second vertical holes **313** formed therein and a flexible printed circuit board **320** are sequentially stacked in step S**419**.

The piezoelectric wafer **350**, arranged in step S**411**, is stacked on the flexible printed circuit board **320**, placed on the rear block **310** in step S**419**, in step S**421**.

When the rear block **310**, the flexible printed circuit board **320**, the piezoelectric wafer **350**, the ground electrode plate **360** and the acoustic matching layer **370** are sequentially stacked in step S**421**, a plurality of slots **383** perpendicular to the first vertical holes **353** are formed such that the slots **383** range from the acoustic matching layer **370** to the top of the rear block **310** in step S**423**.

An acoustic lens (not shown) is bonded onto the acoustic matching layer **370** having the slots **383** formed therein to cover the overall surface of the acoustic matching layer **370** in step S**425**.

The ground electrode plate **360** is connected to a ground layer **359** of the flexible printed circuit board **320** and both ends of the flexible printed circuit board **320** are bonded to each other to connect first and second wiring patterns (not shown) to thereby construct a circuit in step S**427**.

The ultrasonic probe, the ultrasonic imaging apparatus and the fabricating method thereof according to the present invention have been described through embodiments. While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. An ultrasonic probe comprising:

a rear block having a predetermined thickness;

a flexible printed circuit board stacked on the rear block to surround the top face and side of the rear block and having wiring patterns formed thereon;

a piezoelectric wafer stacked on the top face of the flexible printed circuit board and having upper and lower electrodes respectively formed on top and bottom faces thereof;

a ground electrode plate stacked on the top face of the piezoelectric wafer, bonded to the upper electrode and connected to a ground layer of the flexible printed circuit board;

an acoustic matching layer stacked on the top face of the ground electrode plate; and

an acoustic lens bonded onto the acoustic matching layer;

wherein the piezoelectric wafer has first vertical holes elongated in one horizontal direction,

wherein vertical slots are formed in the acoustic matching layer, the ground electrode plate, the piezoelectric wafer and the flexible printed circuit board, and are elongated in another horizontal direction perpendicular to the one horizontal direction,

wherein the flexible printed circuit board comprises:

a base film formed of an insulating material and having a bottom face bonded onto the rear block and a top face opposite to the bottom face; and

wiring patterns formed on both faces of the base film,

wherein the wiring patterns comprises:

a central wiring pattern that is formed on the top face of the base film, has a central pad formed between neighboring first vertical holes, and is extended to the bottom face of the base film through a via;

a first wiring pattern that has a first pad formed adjacent to one side of the central pad, and is extended to one side of the top face of the base film;

a second wiring pattern that has a second pad formed adjacent to the opposite side of the central pad, and is extended to the opposite side of the top face of the base film;

a protective layer formed on the top face of the base film so as to cover the first and second wiring patterns except the first and second pads, and formed on the bottom face of the base film so as to cover the central wiring pattern except the central pad; and

a ground layer formed on the protective layer formed on the top face of the base film, and connected to the ground electrode plate.

2. The ultrasonic probe of claim **1**, wherein the rear block has second vertical holes formed therein, the second vertical holes being vertically extended from the first vertical holes.

3. The ultrasonic probe of claim **1**, wherein the acoustic matching layer has third vertical holes formed therein, the third vertical holes being vertically extended from the first vertical holes.

4. The ultrasonic probe of claim **1**, wherein the rear block has second vertical holes formed therein, the second vertical holes being vertically extended from the first vertical holes, and the acoustic matching layer has third vertical holes formed therein, the third vertical holes being vertically extended from the first vertical holes.

5. The ultrasonic probe of claim **4**, wherein the first, second and third holes have the same size.

6. The ultrasonic probe of claim **5**, wherein the number of first holes, the number of second holes and the number of third holes are two or four.

7. The ultrasonic probe of claim **1**, wherein the central wiring pattern is alternately arranged on one side and the other side of the base film.

8. The ultrasonic probe of claim **7**, wherein both ends of the flexible printed circuit board are bonded to each other such that the first and second wiring patterns are connected to each other.

9. The ultrasonic probe of claim **8**, wherein the central pad, the first pad and the second pad form a 3×96 matrix array.

10. The ultrasonic probe of claim **9**, wherein the number of slots is 95.

11. An ultrasonic imaging apparatus comprising:

the ultrasonic probe according to claim **1**; and

a main body having a connector connected to the ultrasonic probe.

12. The ultrasonic imaging apparatus of claim **11**, wherein the connector is located on the top of the main body.

* * * * *

专利名称(译)	超声波探头，超声波成像装置及其制造方法		
公开(公告)号	US8547799	公开(公告)日	2013-10-01
申请号	US12/699166	申请日	2010-02-03
[标]申请(专利权)人(译)	RHIM SUNG MIN JUNG HO		
申请(专利权)人(译)	RHIM SUNG MIN JUNG HO		
当前申请(专利权)人(译)	HUMANSCAN CO.，LTD.		
[标]发明人	RHIM SUNG MIN JUNG HO		
发明人	RHIM, SUNG MIN JUNG, HO		
IPC分类号	H04R17/00 A61B8/00 G01N29/24		
CPC分类号	A61B8/00 A61B8/4455 A61B8/4483 B06B1/0629		
优先权	1020090010661 2009-02-10 KR		
其他公开文献	US20100204583A1		
外部链接	Espacenet USPTO		

摘要(译)

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