US 20150119718A1

(19) **United States**

(12) **Patent Application Publication**

JIN et al.

(10) **Pub. No.: US 2015/0119718 A1**

(43) **Pub. Date: Apr. 30, 2015**

(54) **ULTRASONIC PROBE AND ULTRASONIC IMAGING APPARATUS**

(71) Applicant: **SAMSUNG MEDISON CO., LTD.**, Gangwon-Do (KR)

(72) Inventors: **Gil Ju JIN**, Seoul (KR); **Sung Do KWON**, Yongin-Si (KR)

(21) Appl. No.: **14/507,681**

(22) Filed: **Oct. 6, 2014**

(30) **Foreign Application Priority Data**

Oct. 29, 2013 (KR) 10-2013-0129098

Publication Classification

(51) **Int. Cl.**

A61B 8/00 (2006.01)
H01L 41/113 (2006.01)
A61B 8/08 (2006.01)
B06B 1/06 (2006.01)

(52) **U.S. Cl.**

CPC *A61B 8/546* (2013.01); *B06B 1/0622* (2013.01); *H01L 41/113* (2013.01); *A61B 8/5207* (2013.01); *A61B 8/5223* (2013.01)

(57) **ABSTRACT**

Provided are an ultrasonic probe that controls temperature of a piezoelectric layer using a thermoelectric element and an ultrasonic imaging apparatus having the same. The ultrasonic probe includes: the piezoelectric layer that vibrates and generates ultrasonic waves if a current is supplied to the piezoelectric layer; and a thermoelectric element that contacts one surface of the piezoelectric layer and controls the temperature of the piezoelectric layer if a current is supplied to the thermoelectric element.

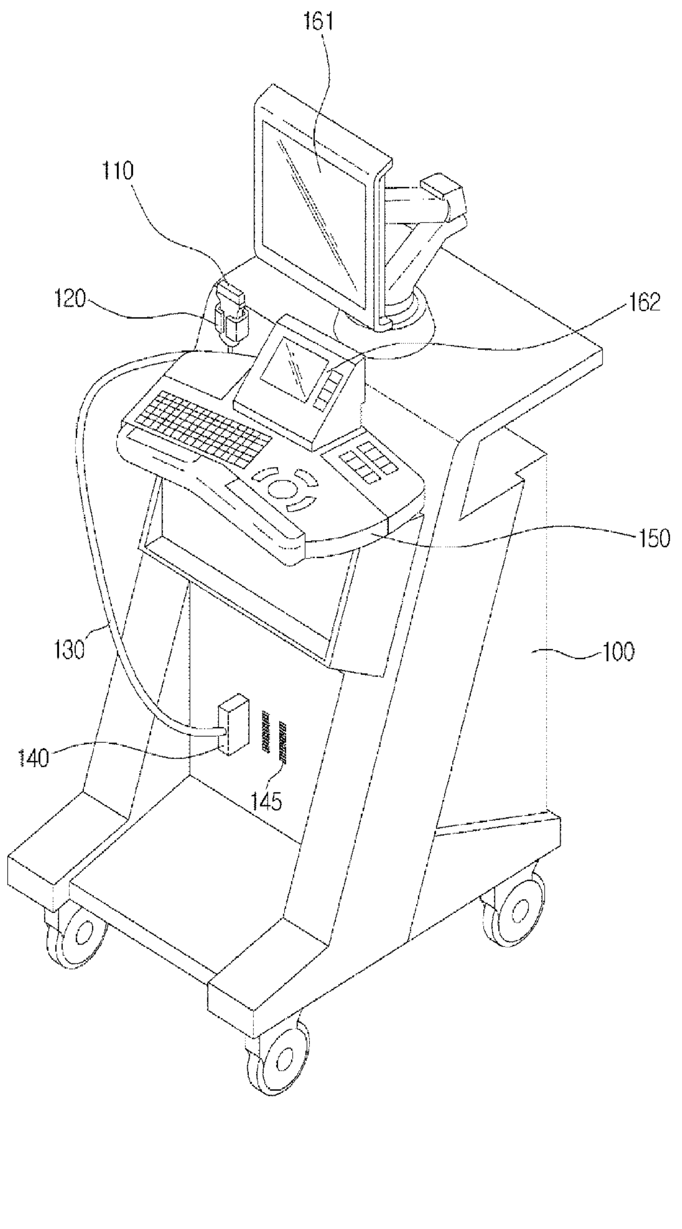


FIG. 1

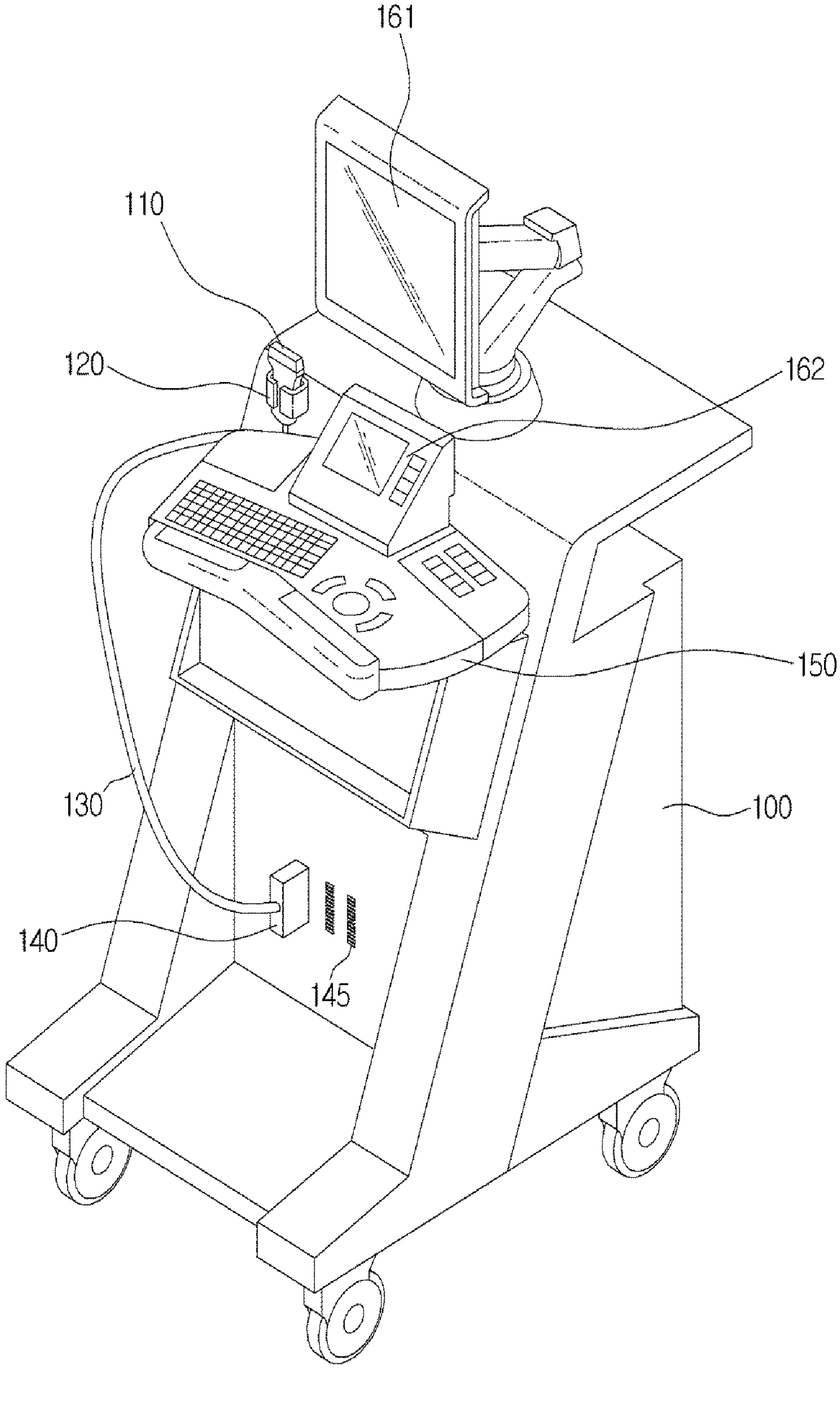


FIG. 2A

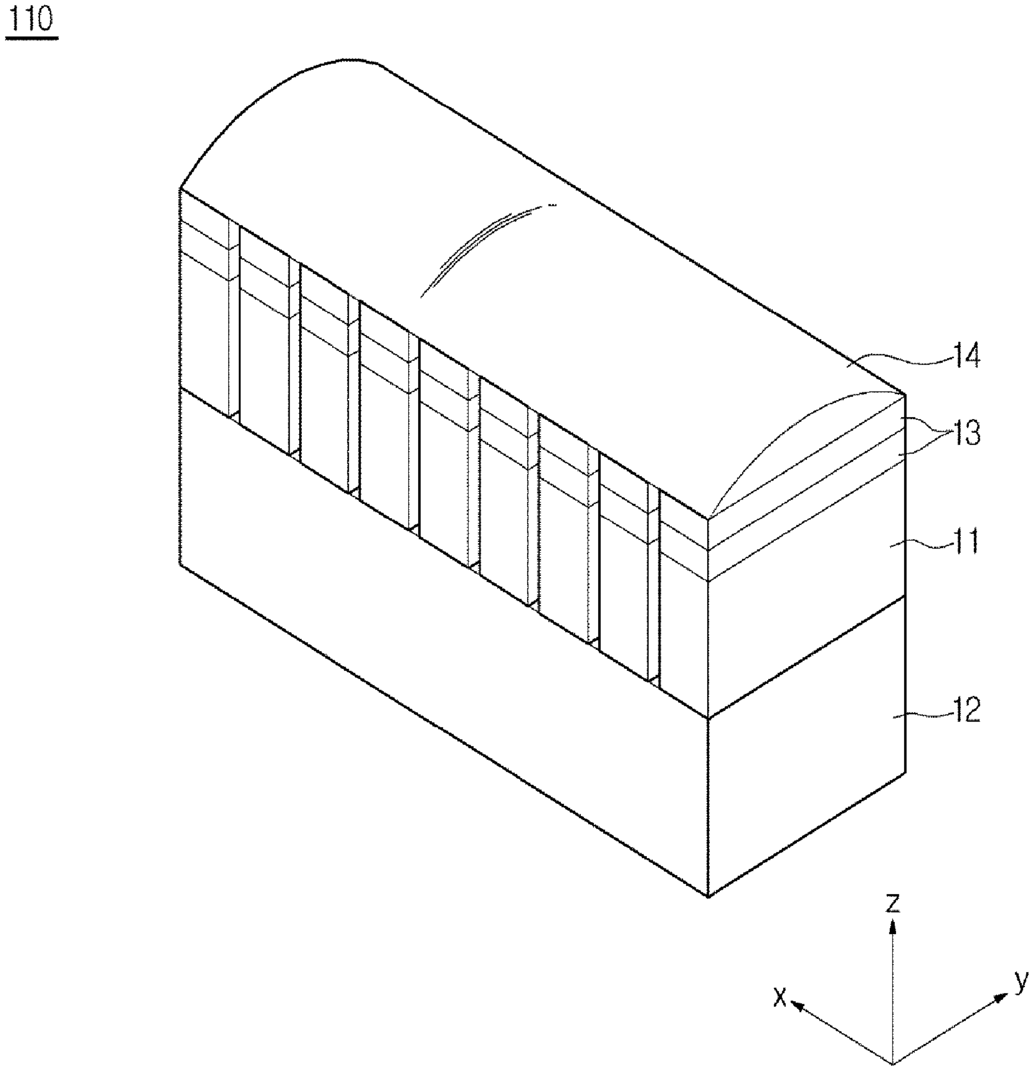


FIG. 2B

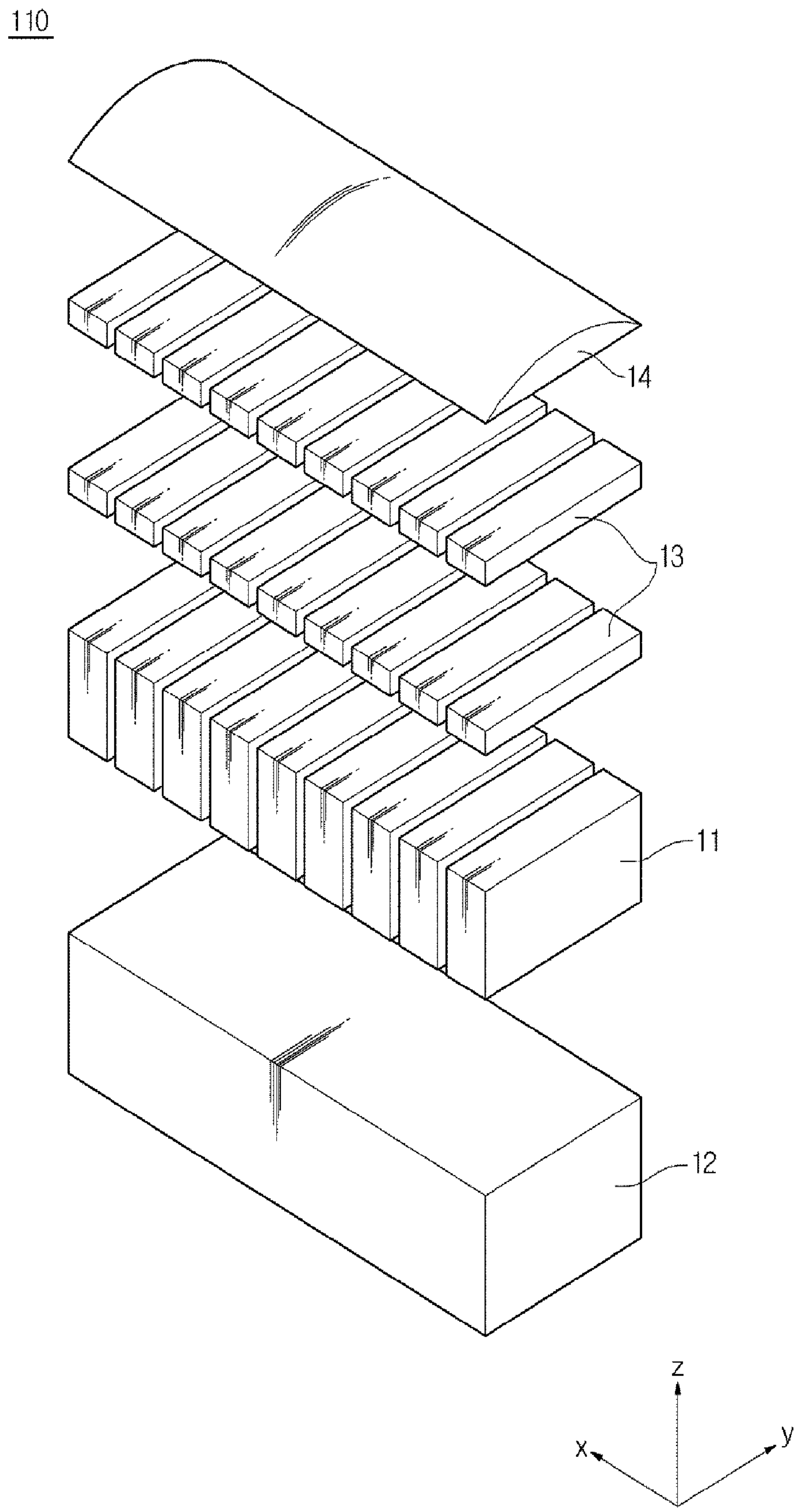


FIG. 3

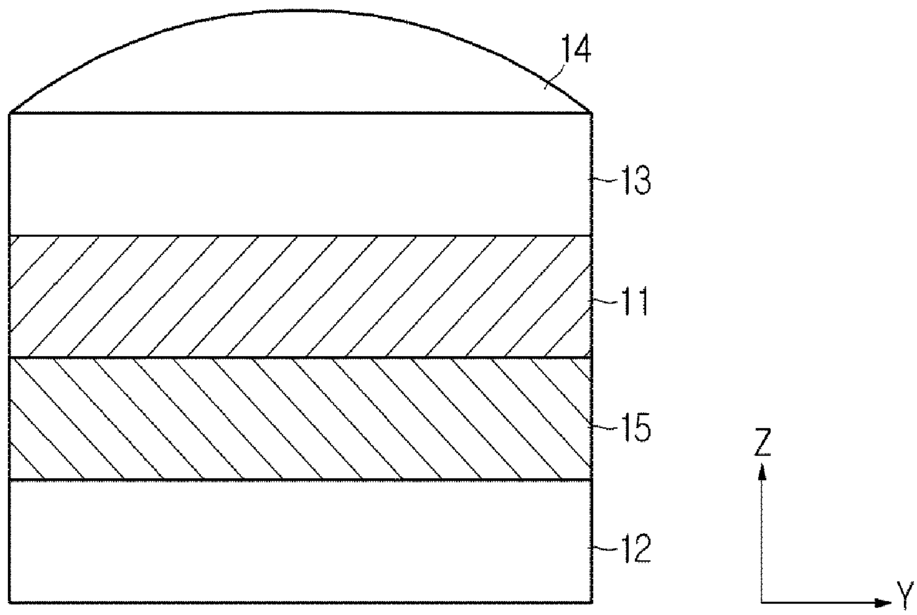


FIG. 4A

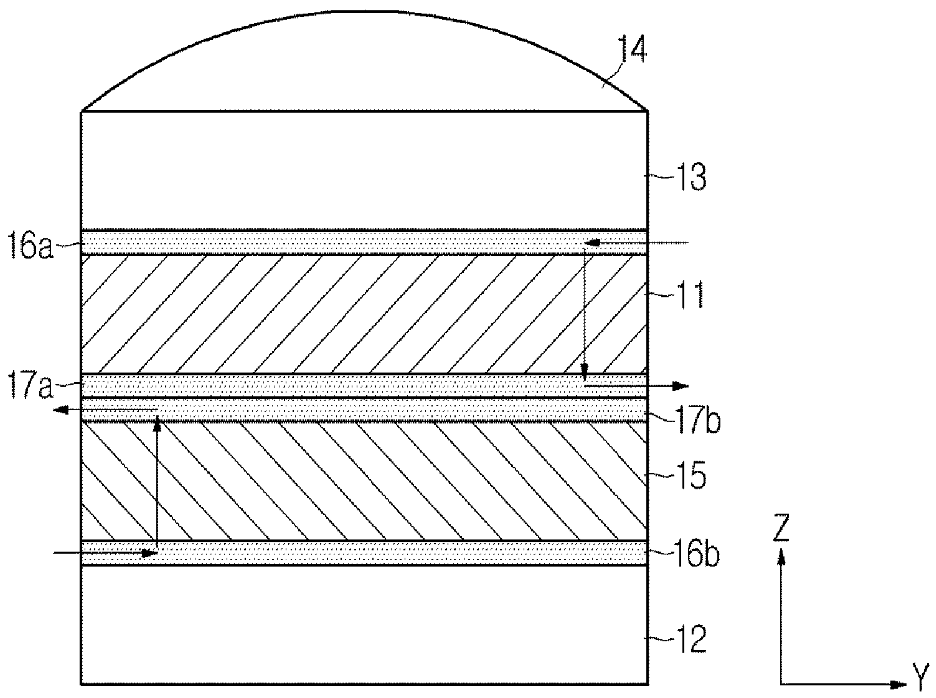


FIG. 4B

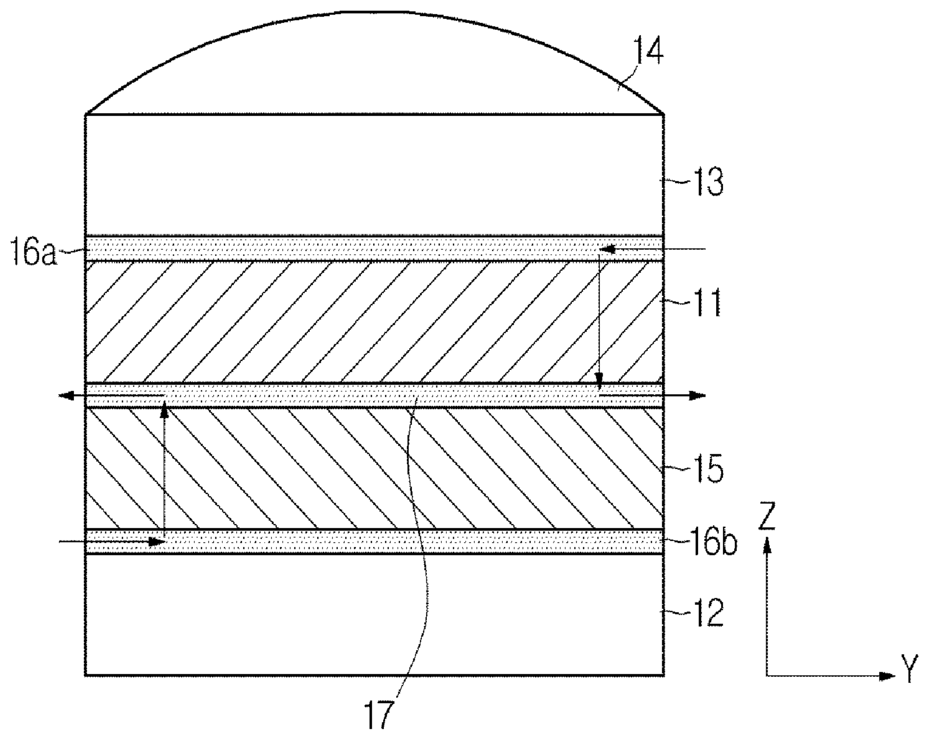


FIG. 4C

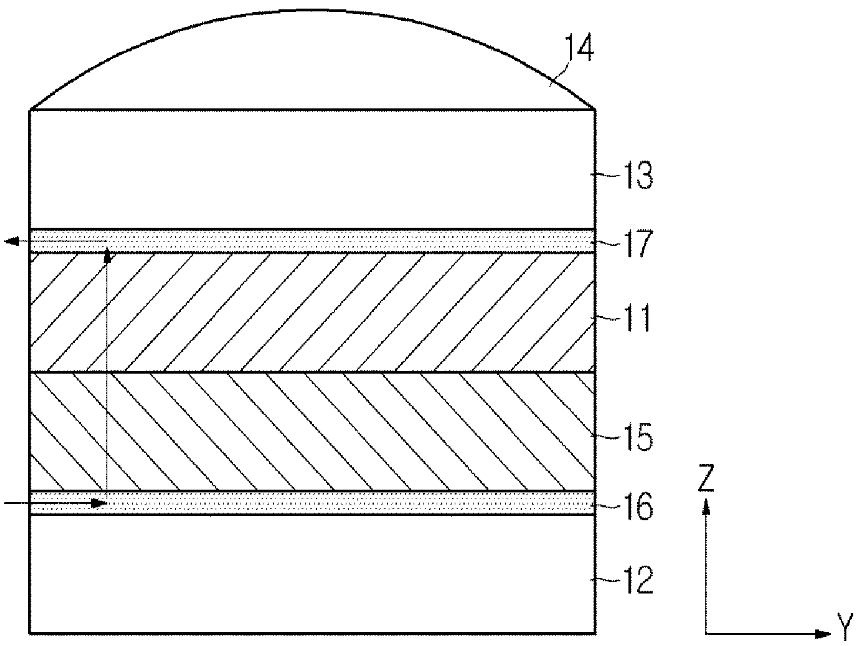


FIG. 5A

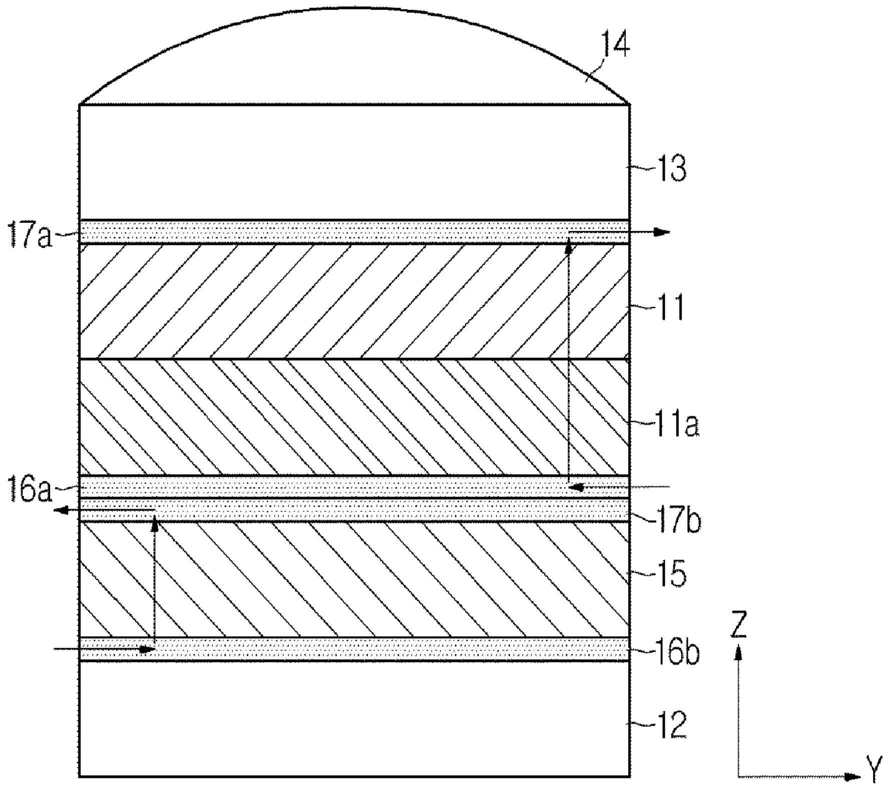


FIG. 5B

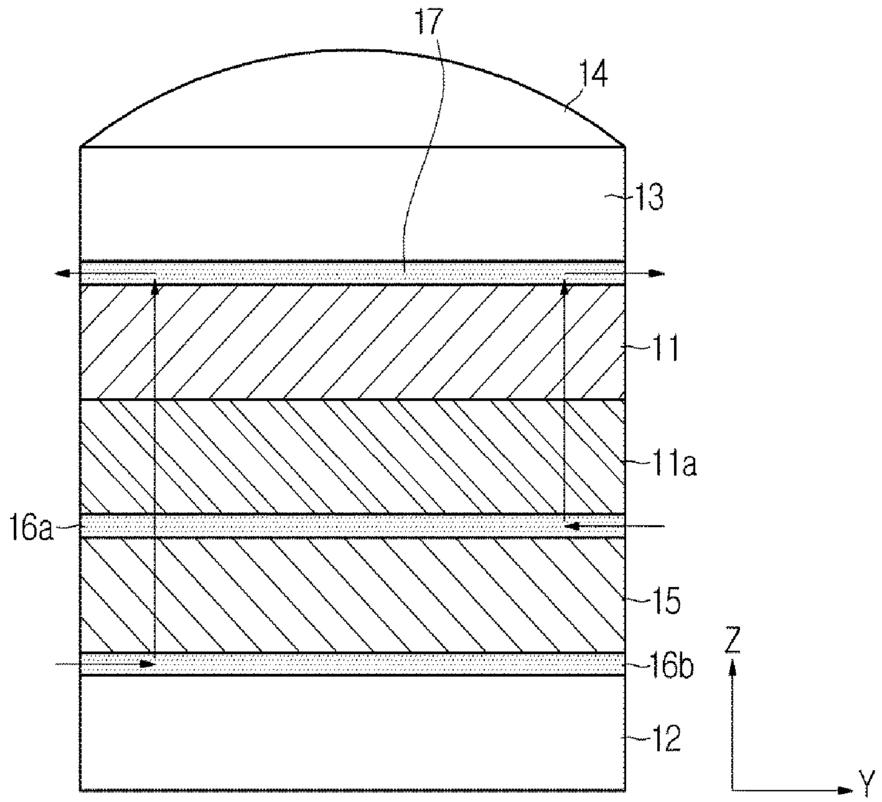


FIG. 5C

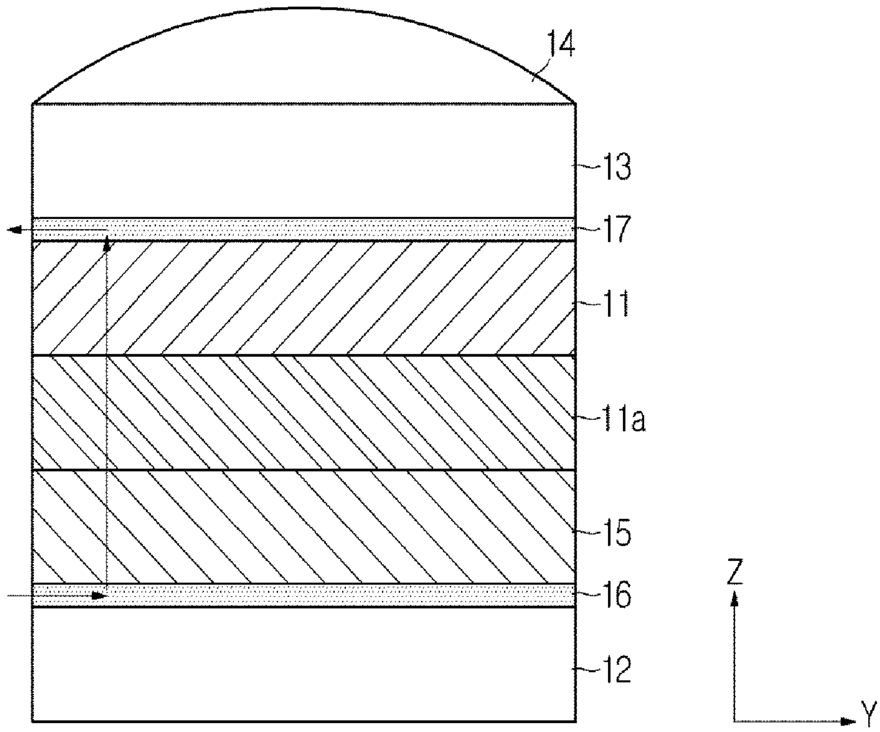


FIG. 5D

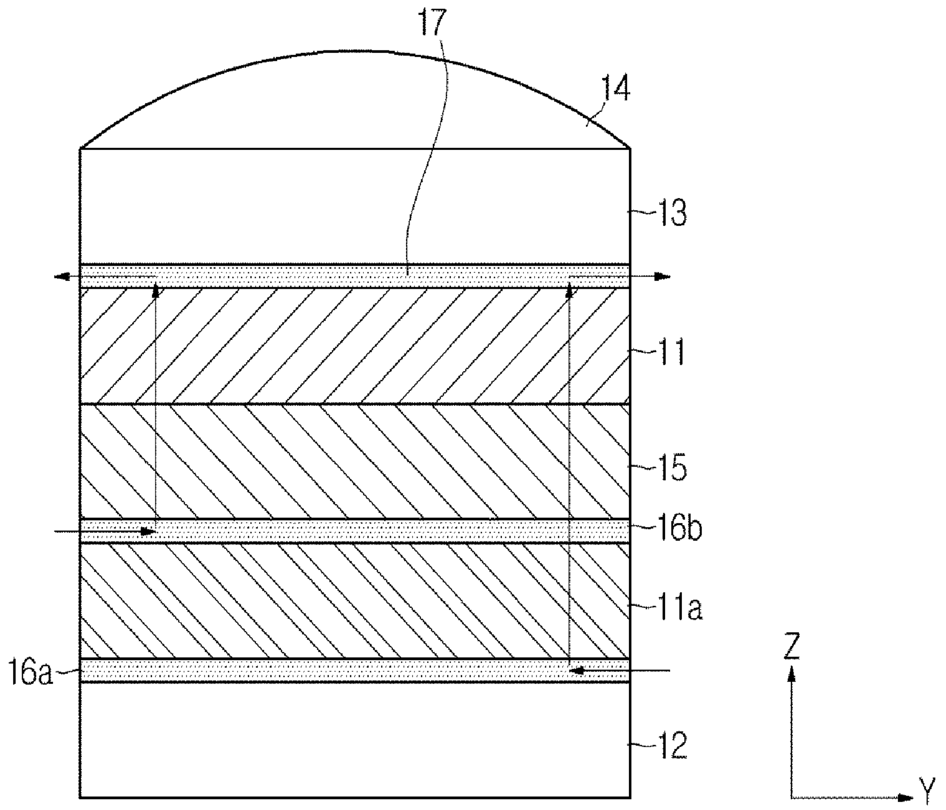


FIG. 5E

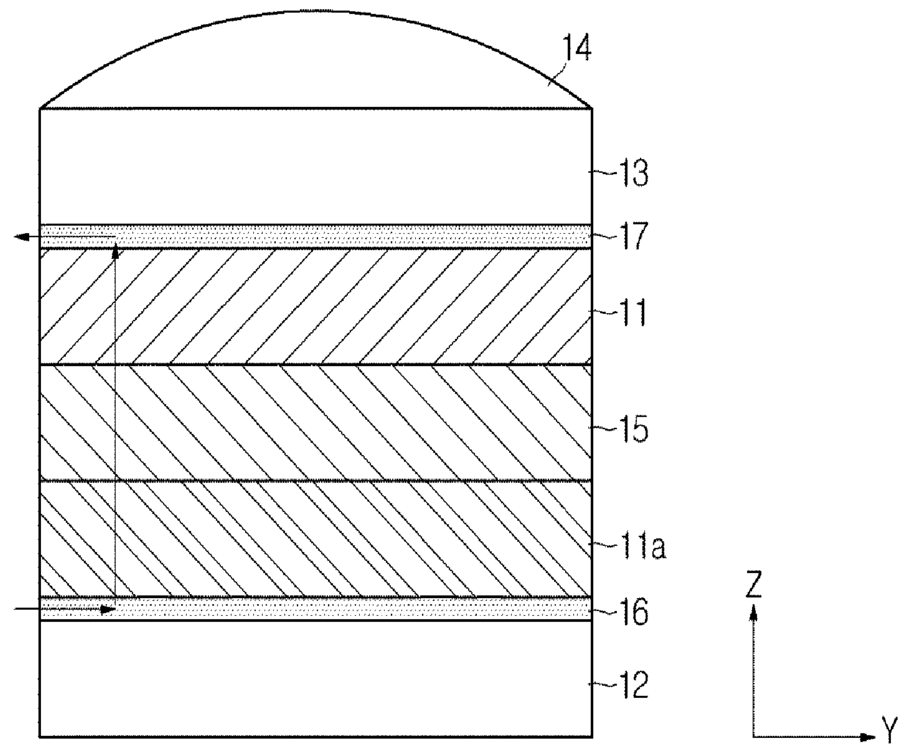


FIG. 6A

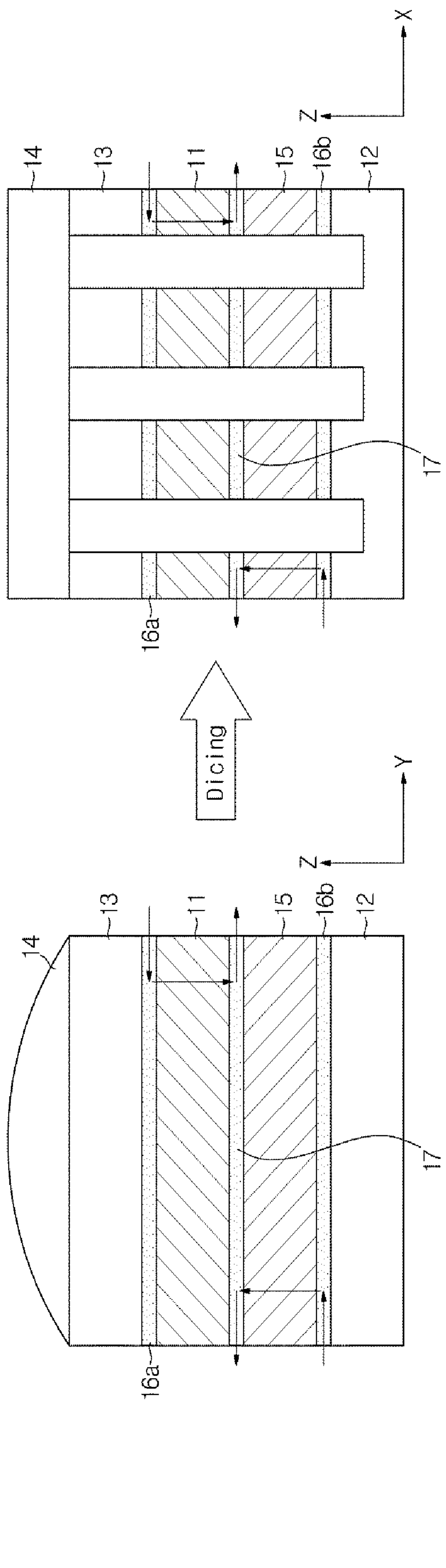


FIG. 6B

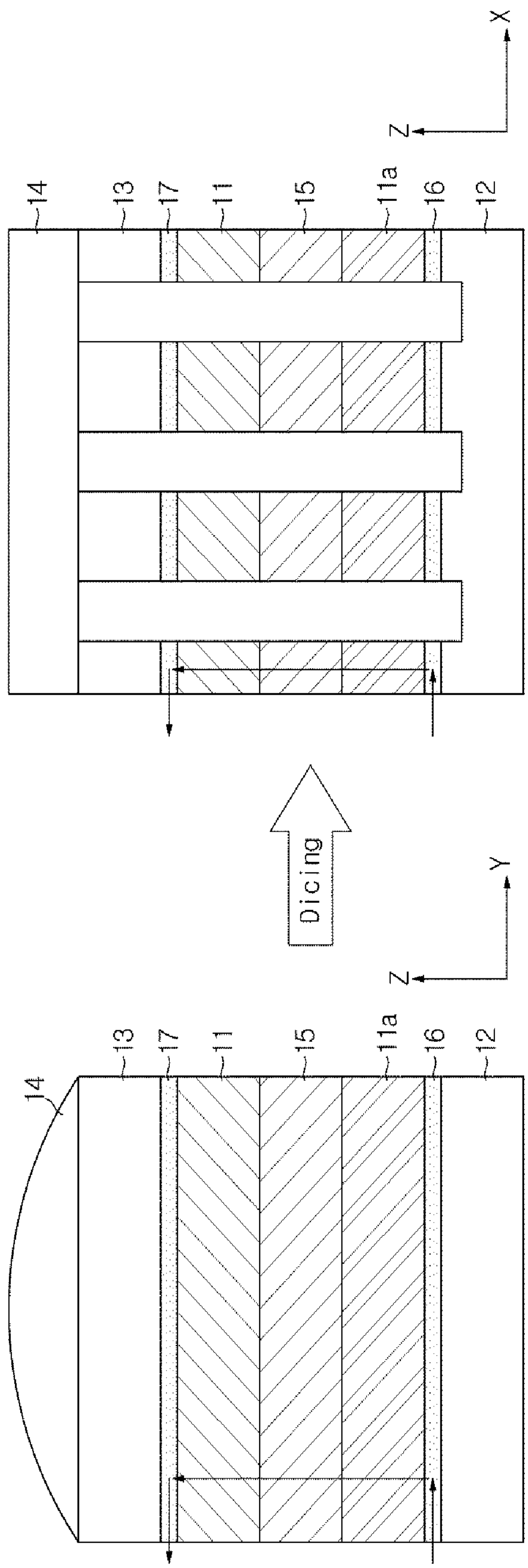
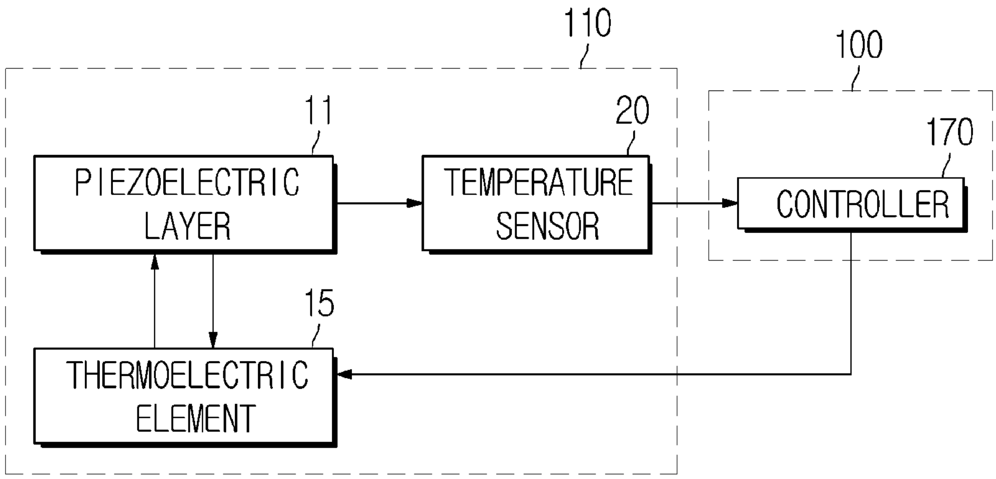


FIG. 7


110
100
11
20
170
PIEZOELECTRIC LAYER
TEMPERATURE SENSOR
CONTROLLER
15
THERMOELECTRIC ELEMENT

ULTRASONIC PROBE AND ULTRASONIC IMAGING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. P2013-0129098, filed on Oct. 29, 2013 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field

[0003] Embodiments of the present invention relate to an ultrasonic probe for generating an image of an inside of a subject using ultrasonic waves and an ultrasonic imaging apparatus having the same.

[0004] 2. Description of the Related Art

[0005] Ultrasonic diagnosis apparatuses are apparatuses that radiate ultrasonic signals onto a target part of a body from a body surface of the subject and obtain a tomogram of a soft tissue or an image of a blood flow of the soft tissue using information regarding reflected ultrasonic signals (ultrasonic echo signals) in a noninvasive manner.

[0006] In comparison with other image diagnosis apparatuses, such as X-ray diagnosis apparatuses, X-ray computerized tomography (CT) scanners, magnetic resonance imaging (MRI) apparatuses, and nuclear medicine apparatuses, ultrasonic diagnosis apparatuses are small-sized and cheap, can be displayed in real time and have high safety due to lack of radiation exposure. Thus, ultrasonic diagnosis apparatuses are widely used in heart, abdominal, urinary, and ob-gyn diagnoses.

[0007] Meanwhile, an ultrasonic probe that radiates ultrasonic waves may include a transducer installed in the ultrasonic probe. An inner side of the ultrasonic probe is required to be maintained at an appropriate temperature so that the transducer operates normally.

SUMMARY

[0008] Therefore, it is an aspect of the present invention to provide an ultrasonic probe that controls temperature of a piezoelectric layer using a thermoelectric element, and an ultrasonic imaging apparatus having the same.

[0009] Additional aspects 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.

[0010] In accordance with one aspect of the present invention, an ultrasonic probe includes: a piezoelectric layer that vibrates and generates ultrasonic waves if a current is supplied to the piezoelectric layer; and a thermoelectric element that contacts one surface of the piezoelectric layer and controls temperature of the piezoelectric layer if a current is supplied to the thermoelectric element.

[0011] The thermoelectric element may include: a heat dissipation plate that is disposed on one surface of the thermoelectric element and dissipates heat toward a contact surface between the piezoelectric layer and the thermoelectric element; and a heat absorption plate that is disposed at an opposite side to the heat dissipation plate and absorbs heat of the contact surface.

[0012] The thermoelectric element may contact the piezoelectric layer through the heat dissipation plate and may heat the piezoelectric layer.

[0013] The thermoelectric element may contact the piezoelectric layer through the heat absorption plate and may cool the piezoelectric layer.

[0014] The piezoelectric layer and the thermoelectric element may share a signal electrode through which a current is supplied to the piezoelectric layer and the thermoelectric element, respectively.

[0015] The piezoelectric layer and the thermoelectric element may share a ground electrode.

[0016] When the piezoelectric layer includes one or more piezoelectric channels, the thermoelectric element may include one or more thermoelectric channels corresponding to the one or more piezoelectric channels.

[0017] In accordance with another aspect of the present invention, an ultrasonic probe includes: a piezoelectric layer that vibrates and generates ultrasonic waves if a current is supplied to the piezoelectric layer; an application specific integrated circuit (ASIC) that transfers the current to the piezoelectric layer; and a thermoelectric element that contacts one surface of the ASIC and controls temperature of the piezoelectric layer if a current is supplied to the thermoelectric element.

[0018] The thermoelectric element may include: a heat dissipation plate that is disposed on one surface of the thermoelectric element and dissipates heat toward a contact surface between the piezoelectric layer and the thermoelectric element; and a heat absorption plate that is disposed at an opposite side to the heat dissipation plate and absorbs heat of the contact surface.

[0019] The piezoelectric layer and the thermoelectric element may share a signal electrode through which a current is supplied to the piezoelectric layer and the thermoelectric element, respectively.

[0020] The piezoelectric layer and the thermoelectric element may share a ground electrode.

[0021] In accordance with still another aspect of the present invention, an ultrasonic imaging apparatus includes: an ultrasonic probe including a piezoelectric layer that vibrates and generates ultrasonic waves, a thermoelectric element that contacts one surface of the piezoelectric layer and controls temperature of the piezoelectric layer according to a supplied current, and a temperature sensor that senses the temperature of the piezoelectric layer; and a controller that controls the supplied current based on the sensed temperature.

[0022] In accordance with yet still another aspect of the present invention, an ultrasonic imaging apparatus includes: an ultrasonic probe including a piezoelectric layer that vibrates and generates ultrasonic waves, an application specific integrated circuit (ASIC) that transfers a current to the piezoelectric layer, a thermoelectric element that contacts one surface of the ASIC and controls temperature of the piezoelectric layer according to the supplied current, and a temperature sensor that senses the temperature of the piezoelectric layer; and a controller that controls the supplied current based on the sensed temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] These and/or other aspects of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

[0024] FIG. **1** is a perspective view of an ultrasonic imaging apparatus in accordance with an embodiment of the present invention;

[0025] FIG. **2**A is a perspective of an ultrasonic probe according to the related art, and FIG. **2**B is an exploded perspective view of the ultrasonic probe illustrated in FIG. 2A;

[0026] FIG. **3** illustrates an ultrasonic probe including a thermoelectric element, in accordance with an embodiment of the present invention;

[0027] FIGS. **4**A through **4**C illustrate ultrasonic probes including a signal electrode and a ground electrode, in accordance with other embodiments of the present invention;

[0028] FIGS. **5**A through **5**E illustrate ultrasonic probes including an application specific integrated circuit (ASIC), in accordance with various embodiments of the present invention;

[0029] FIGS. **6**A and **6**B illustrate ultrasonic probes in which a piezoelectric layer is diced, in accordance with other embodiments of the present invention; and

[0030] FIG. **7** is a control block diagram of an ultrasonic imaging apparatus including the ultrasonic probe in which the thermoelectric element is disposed, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0031] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0032] FIG. **1** is a perspective view of an ultrasonic imaging apparatus in accordance with an embodiment of the present invention. As illustrated in FIG. **1**, the ultrasonic imaging apparatus may include a body **100**, an ultrasonic probe **110**, an input unit **150**, and a display **160**. In this case, the display **160** may include a main display **161** and a subdisplay **162**.

[0033] One or more female connectors **145** may be provided at one side of the body **100**. A male connector **140** connected to a cable **130** may be physically coupled to the female connector **145**.

[0034] A plurality of casters (not shown) for mobility of the ultrasonic imaging apparatus may be provided at a lower portion of the body **100**. The plurality of casters (not shown) may fix the ultrasonic imaging apparatus at a particular place or may move the ultrasonic imaging apparatus in a particular direction.

[0035] The ultrasonic probe **110** that contacts a body surface of a subject may transmit and receive ultrasonic waves. One end of the cable **130** may be connected to the ultrasonic probe **110**, and the male connector **140** may be connected to the other end of the cable **130**. The male connector **140** connected to the other end of the cable **130** may be physically coupled to the female connector **145** of the body **100**.

[0036] Instructions relating to an operation of the ultrasonic imaging apparatus may be input to the input unit **150**. For example, mode selection instructions, such as an amplitude mode (A-mode), a brightness mode (B-mode), and a motion mode (M-mode), or ultrasonic diagnosis starting instructions may be input to the input unit **150**. The instructions input through the input unit **150** may be transmitted to the body **100** through wired or wireless communication.

[0037] The input unit **150** may include at least one of a keyboard, a foot switch, and a foot pedal, for example. The keyboard may be implemented with hardware and may be placed at an upper portion of the body **100**. The keyboard may include at least one of a switch, a key, a joystick, and a trackball. Alternatively, the keyboard may be implemented with software, like a graphic user interface. In this case, the keyboard may be displayed on the subdisplay **162** or the main display **161**. The foot switch or the foot pedal may be disposed at the lower portion of the body **100**, and a manipulator may control the operation of the ultrasonic imaging apparatus using the foot pedal.

[0038] An ultrasonic probe holder **120** for holding the ultrasonic probe **110** may be disposed around the input unit **150**. One or more ultrasonic probe holders **120** may be provided. When an inspector does not use the ultrasonic imaging apparatus, the ultrasonic probe **110** may be held by and kept in the ultrasonic probe holder **120**.

[0039] The subdisplay **162** may be disposed on the body **100**. FIG. **1** illustrates a case that the subdisplay **162** is disposed at an upper portion of the input unit **150**. The subdisplay **162** may display an application relating to the operation of the ultrasonic imaging apparatus. For example, the subdisplay **162** may display a menu or information required for ultrasonic diagnosis. The subdisplay **162** may be implemented with a cathode ray tube (CRT) or a liquid crystal display (LCD), for example.

[0040] The main display **161** may be disposed at the body **100**. FIG. **1** illustrates a case that the main display **161** is disposed at an upper portion of the subdisplay **162**. The main display **161** may display an ultrasonic image obtained during an ultrasonic diagnosis procedure. The main display **161** may be implemented with a CRT or an LCD, like in the subdisplay **162**. Although FIG. **1** illustrates a case that the main display **161** is coupled to the body **100**, the main display **161** may be implemented to be detachable from the body **100**.

[0041] FIG. **1** illustrates a case that both the main display **161** and the subdisplay **162** are provided at the ultrasonic imaging apparatus. However, the subdisplay **162** may be omitted, as needed. In this case, the application or menu displayed on the subdisplay **162** may be displayed on the main display **161**.

[0042] Until now, a general configuration of the ultrasonic imaging apparatus has been described. Hereinafter, an ultrasonic probe according to the present invention will be described in more detail.

[0043] FIG. **2**A is a perspective of an ultrasonic probe according to the related art, and FIG. **2**B is an exploded perspective view of the ultrasonic probe illustrated in FIG. 2A.

[0044] An ultrasonic probe **110** according to the related art may include a piezoelectric layer **11**, a matching layer **13** disposed on a top surface of the piezoelectric layer **11**, a lens **14** installed at a top surface of the matching layer **13**, and a backing layer **12** disposed on a bottom surface of the piezoelectric layer **11**.

[0045] The effects that, if mechanical pressure is applied to a predetermined material, a voltage is generated and if a voltage is applied to the predetermined material, mechanical deformation occurs, are referred to as a piezoelectric effect and an inverse piezoelectric effect, and a material having these effects is referred to as a piezoelectric material. That is, the piezoelectric material is a material that transforms electric energy into mechanical vibration energy or vice versa.

[0046] The ultrasonic probe **110** of FIG. **1** includes the piezoelectric layer **11** that transforms a received electrical signal into mechanical vibration so as to generate ultrasonic waves.

[0047] The piezoelectric material that constitutes the piezoelectric layer **11** may include a ceramic of lead zirconate titanate (PZT), a PZMT monocrystal formed of a solid solution of lead magnesium niobate (PMN) and lead titanate (PT), or a PZNT monocrystal formed of a solid solution of lead zinc niobate (PZN) and PT.

[0048] The backing layer **12** is mounted on the bottom surface of the piezoelectric layer **11**, absorbs the ultrasonic waves generated in the piezoelectric layer **11**, and blocks the ultrasonic waves that proceed toward the bottom surface of the piezoelectric layer **11**, thereby preventing distortion of an image. The backing layer **12** may be manufactured as a plurality of layers so as to improve an attenuation or blocking effect of the ultrasonic waves.

[0049] The matching layer **13** is disposed on the top surface of the piezoelectric layer **11** and reduces a difference in sound impedance between the piezoelectric layer **11** and the subject so that ultrasonic waves generated in the piezoelectric layer **11** can be effectively transferred to the subject. The matching layer **13** may be formed to have one or more layers.

[0050] The matching layer **13** may be divided into a plurality of units having predetermined widths together with the piezoelectric layer **11** through a dicing process.

[0051] Although not shown, a protective layer may be disposed on the top surface of the matching layer **13**. The protective layer may prevent outflow of high frequency components that may be generated in the piezoelectric layer **11** and may block inflow of external high frequency signals. Also, the protective layer may protect internal parts of the ultrasonic probe from water or medicine used in disinfection by coating or depositing a conductive material on the surface of a film having moisture tolerance and chemical resistance.

[0052] The lens **14** is installed at the top surface of the matching layer **13**. The lens **14** may have a convex shape in a radiation direction of the ultrasonic waves so as to focus the ultrasonic waves, and when sound speed is slower than the human body, the lens **14** may be implemented with a concave shape.

[0053] Meanwhile, all parts of vibration of the piezoelectric layer **11** are not transformed into ultrasonic waves but parts thereof are converted into heat, and thus a sound loss occurs. Heat generated in this way may increase an internal temperature of the ultrasonic probe **110** to 40° C. or higher. Since the high-temperature ultrasonic probe **110** directly contacts a skin, a patient's health may be under threat. If heat generated in the piezoelectric layer **11** is not properly dissipated, performance of the ultrasonic probe **110** may be adversely affected. In particular, a depolarization phenomenon may occur in the piezoelectric material that constitutes the piezoelectric layer **11** in a high-temperature environment. This may cause performance of the piezoelectric layer **11** to be degraded.

[0054] When the ultrasonic probe **110** is in a high-temperature state and in an extremely low temperature environment, performance degradation may occur. Thus, the temperature of the ultrasonic probe **110**, in detail, the temperature of the piezoelectric layer **11** is required to be uniformly maintained regardless of a peripheral environment.

[0055] FIG. **3** illustrates an ultrasonic probe including a thermoelectric element, in accordance with an embodiment of the present invention.

[0056] As illustrated in FIG. **3**, a thermoelectric element **15** may contact one surface of the piezoelectric layer **11** so as to control the temperature of the piezoelectric layer **11**. Here, the thermoelectric element **15** is an element that uses the peltier effect that one terminal causes a heat absorption reaction and the other terminal causes a heat dissipation reaction according to a direction of a current if ends of different types of metals are connected to each other and a current flows through the connected metal ends.

[0057] In an embodiment of the thermoelectric element **15**, the thermoelectric element **15** may include a heat dissipation plate that is disposed at one surface of the thermoelectric element **15** and dissipates heat, and a heat absorption plate that is disposed at an opposite side to the heat dissipation plate and absorbs heat.

[0058] In this case, the used thermoelectric element **15** may be a thin film type thermoelectric element **15**. The thickness of the thermoelectric element **15** may be several tens of micrometers (um) to several hundreds of micrometers (um). The thinner the thermoelectric element **15**, the less effect on sound performance of the piezoelectric layer **11**, but performance of the thermoelectric element **15** is degraded. Thus, an appropriate thickness of the thermoelectric element **15** may be determined according to situations and may be applied to the ultrasonic probe **110**.

[0059] If the thermoelectric element **15** contacts one surface of the piezoelectric layer **11** through the heat dissipation plate, the heat dissipation plate may dissipate heat and may heat the piezoelectric layer **11**. In contrast, if the thermoelectric element **15** contacts one surface of the piezoelectric layer **11** through the heat absorption plate, the heat absorption plate may absorb heat generated in the piezoelectric layer **11** and may cool the piezoelectric layer **11**.

[0060] FIG. **3** illustrates the ultrasonic probe **110** in which the thermoelectric element **15** contacts a bottom surface of the piezoelectric layer **11**, in accordance with an embodiment of the present invention. The piezoelectric layer **11** and the thermoelectric element **15** may make surface contact with each other and may be configured such that conduction of heat may be easily performed. In this case, a thermal compound may be used to improve the effects of surface contact.

[0061] When ultrasonic diagnosis is performed in an extremely low-temperature environment, the piezoelectric layer **11** needs to be heated for a normal operation of the ultrasonic probe **110**. To this end, the heat dissipation plate may be disposed on a top surface of the thermoelectric element **15**, i.e., on a surface that makes surface contact with the piezoelectric layer **11**. Heat generated in the heat dissipation plate provided in this way may be transferred to the piezoelectric layer **11**, and the piezoelectric layer **11** to which heat is transferred, may be maintained at a uniform temperature and may generate ultrasonic waves normally.

[0062] Alternatively, an internal temperature of the ultrasonic probe **110** may be increased due to heat generated due to vibration of the piezoelectric layer **11**. If heat generated in this way is not dissipated, normal ultrasonic diagnosis becomes difficult. To this end, the heat absorption plate may be disposed on the top surface of the thermoelectric element **15**, i.e., on a surface that makes surface contact with the piezoelectric layer **11**. Heat generated in the piezoelectric layer **11** is absorbed by the heat absorption plate so that the piezoelectric layer **11** may be cooled and the internal temperature of the ultrasonic probe **110** may be prevented from being increased.

[0063] As a result, the piezoelectric layer **11** and the thermoelectric element **15** make surface contact with each other so that the piezoelectric layer **11** can be maintained at a uniform temperature and the ultrasonic probe **110** can operate normally.

[0064] FIGS. **4**A through **4**C illustrate ultrasonic probes including a signal electrode and a ground electrode, in accordance with embodiments of the present invention. Arrows in FIGS. **4**A through **4**C mean a direction in which a current flows.

[0065] The current may be supplied to the piezoelectric layer **11** so that the piezoelectric layer **11** generates ultrasonic waves. To this end, the piezoelectric layer **11** may include a signal electrode **16***a* for the piezoelectric layer **11** to which the current is supplied, and a ground electrode **17***a* for the piezoelectric layer **11** through which the current is discharged. If the current is supplied to the piezoelectric layer **11** via the signal electrode **16***a* for the piezoelectric layer **11**, the piezoelectric layer **11** vibrates and generates ultrasonic waves.

[0066] Since the thermoelectric element **15** generates a temperature difference between both ends of the thermoelectric element **15** due to the peltier effect, a supply of current is required. To this end, the thermoelectric element **15** may include a signal electrode **16***b* for the thermoelectric element **15** to which a current is supplied, and a ground electrode **17***b* for the thermoelectric element **15** through which the current is discharged. The thermoelectric element **15** generates a temperature difference between both ends of the thermoelectric element **15** due to the current supplied to the thermoelectric element **15** through the signal electrode **16***b*, thereby controlling the temperature of the piezoelectric layer **11**.

[0067] FIG. **4**A illustrates the ultrasonic probe **110** in which the piezoelectric layer **11** and the thermoelectric element **15** make surface contact with each other, i.e., a case that a signal electrode and a ground electrode are disposed on the piezoelectric layer **11** an the thermoelectric element **15**, respectively, in accordance with an embodiment of the present invention. In this case, a current is supplied to the piezoelectric layer **11** through the signal electrode **16***a* for the piezoelectric layer **11**, and a current is supplied to the thermoelectric element **15** through the signal electrode **16***b* for the thermoelectric element **15**. Thus, the piezoelectric layer **11** and the thermoelectric element **15** operate due to separate currents.

[0068] FIG. **4**B illustrates the ultrasonic probe **110** in which the piezoelectric layer **11** and the thermoelectric element **15** make surface contact with each other, i.e., a case that the piezoelectric layer **11** and the thermoelectric element **15** share a ground electrode, in accordance with another embodiment of the present invention. In this case, a current is supplied to the piezoelectric layer **11** through the signal electrode **16***a* for the piezoelectric layer **11**, and a current is supplied to the thermoelectric element **15** through the signal electrode **16***b* for the thermoelectric element **15**, like in FIG. **4**A. However, there is a difference between FIGS. **4**A and **4**B in that, in FIG. **4**B, the current flows to the ground through one ground electrode. Hereinafter, the ground electrode shared by the piezoelectric layer **11** and the thermoelectric element **15** is referred to as a shared ground electrode **17**.

[0069] As illustrated in FIG. **4**B, if the piezoelectric layer **11** and the thermoelectric element **15** share the ground electrode, only one ground electrode is sufficient. Connection lines connected to the outside are required to be provided in each electrode. If the number of electrodes is reduced, the number of connection lines that accompany with the number of electrodes is also reduced to overcome a limitation in an internal space of the ultrasonic probe **110**.

[0070] Also, even when the piezoelectric layer **11** and the thermoelectric element **15** are diced, the risk of generating an electrical short is low. In addition, interference that occurs between a plurality of electrode layers is reduced so that sound performance can be uniformly maintained.

[0071] FIG. **4**C illustrates the ultrasonic probe **110** in which the piezoelectric layer **11** and the thermoelectric element **15** make surface contact with each other, i.e., a case that the piezoelectric layer **11** and the thermoelectric element **15** share a ground electrode and a signal electrode, in accordance with still another embodiment of the present invention. Hereinafter, the signal electrode shared by the piezoelectric layer **11** and the thermoelectric element **15** is referred to as a shared signal electrode **16**.

[0072] Referring to FIG. **4**C, a current may be supplied to the thermoelectric element **15** via the shared signal electrode **16** disposed on a bottom surface of the thermoelectric element **15**. A surface of the thermoelectric element **15** on which the shared signal electrode **16** is disposed, may be a heat dissipation plate. When the supplied current flows from the heat dissipation plate to the heat absorption plate, a temperature difference may be generated in both ends of the thermoelectric element **15**. As a result, heat generated in the piezoelectric layer **11** is absorbed by the heat absorption plate, and thus the piezoelectric layer **11** may be cooled.

[0073] Also, the current that flows through the heat absorption plate may be transferred to the piezoelectric layer **11** and may vibrate the piezoelectric layer **11**. The current may be discharged through the shared ground electrode **17** disposed on a top surface of the piezoelectric layer **11**.

[0074] As illustrated in FIG. **4**C, if a current is supplied through the shared signal electrode **16**, a temperature difference of the thermoelectric element **15** may be generated due to the supplied current, and the piezoelectric layer **11** may be vibrated, and ultrasonic waves may be generated. Unlike in FIG. **4**A or **4**B in which the piezoelectric layer **11** and the thermoelectric element **15** are controlled due to separate currents, the piezoelectric layer **11** and the thermoelectric element **15** are controlled when one current flows through the piezoelectric layer **11** and the thermoelectric element **15** via the shared signal electrode **16**.

[0075] In this way, if the piezoelectric layer **11** and the thermoelectric element **15** share the signal electrode as well as the ground electrode, the number of electrodes and the number of connection lines that accompany with the number of electrodes are reduced such that there is no problem of the limitation in the internal space of the ultrasonic probe **110**.

[0076] Also, even when the piezoelectric layer **11** and the thermoelectric element **15** are diced, there is a low possibility that an electrical short will occur. In addition, interference that occurs between a plurality of electrode layers is reduced so that sound performance is not degraded.

[0077] FIGS. **5**A through **5**E illustrate ultrasonic probes including an application specific integrated circuit (ASIC), in accordance with various embodiments of the present invention.

[0078] As the configuration of the ultrasonic probe **110** is recently diversified, complexity of an inside of the ultrasonic probe **110** increases. In particular, as an arrangement shape of a transducer device is complicated, the ultrasonic probe **110** may include an application specific integrated circuit (ASIC) so as to control a current supplied to each device. Owing to integration technology using the ASIC, the reliability of the ultrasonic probe **110** and the ultrasonic imaging apparatus can be increased, and complexity of the ultrasonic probe **110** can be decreased, and excellent signal processing efficiency can be obtained.

[0079] In this way, even when the ultrasonic probe **110** includes the ASIC so as to transfer the current to the piezoelectric layer **11**, the ultrasonic probe **110** may include the thermoelectric element **15** so as to control the temperature of the piezoelectric layer **11**.

[0080] FIGS. **5**A through **5**C illustrate the ultrasonic probe **110** in which an ASIC **11***a* makes surface contact with the bottom surface of the piezoelectric layer **11** and the thermoelectric element **15** makes surface contact with a bottom surface of the ASIC **11***a*, in accordance with various embodiments of the present invention. In this case, since the ASIC **11***a* controls the supplied current and transfers the current to the piezoelectric layer **11**, each embodiment of the ultrasonic probe **110** including the ASIC **11***a* is subject to a case that the supplied current is transferred to the piezoelectric layer **11** via the ASIC **11***a*. Arrows of FIGS. **5**A through **5**E represent a direction in which the current flows.

[0081] FIG. **5**A illustrates a case that the piezoelectric layer **11** includes a signal electrode and a ground electrode for the piezoelectric layer **11** and the thermoelectric element **15** includes a signal electrode and a ground electrode for the thermoelectric element **15**. The signal electrode **16***a* for the piezoelectric layer **11** may be disposed on the ASIC **11***a*, and a current may be supplied to the signal electrode **16***a* for the piezoelectric layer **11**. The current supplied in this way may be controlled by the ASIC **11***a* and may be transferred to the piezoelectric layer **11**, and the piezoelectric layer **11** to which the current is transferred, may vibrate and generate ultrasonic waves. Also, the current is discharged along the ground electrode **17***a* disposed on the piezoelectric layer **11**.

[0082] Meanwhile, the thermoelectric element **15** may include the signal electrode **16***b* and the ground electrode **17***b* for the thermoelectric element **15**. In FIG. **5**A, the signal electrode **16***b* for the thermoelectric element **15** is disposed on the bottom surface of the thermoelectric element **15**. Thus, the bottom surface of the thermoelectric element **15** is a heat dissipation plate. The current supplied along the signal electrode **16***b* for the thermoelectric element **15** flows from the heat dissipation plate to an opposite site, i.e., to a heat absorption plate and is discharged along the ground electrode **17***b* for the thermoelectric element **15**. In this case, the heat absorption plate absorbs heat generated in the piezoelectric layer **11** via the ASIC **11***a* and thus may cool the piezoelectric layer **11**.

[0083] Unlike in FIG. **5**A, FIG. **5**B illustrates a case that the shared ground electrode **17** is disposed. The current supplied along the signal electrode **16***a* for the piezoelectric layer **11** disposed on the ASIC **11***a* vibrates the piezoelectric layer **11** and is discharged along the shared ground electrode **17**. Also, the current supplied along the signal electrode **16***b* for the thermoelectric element **15** disposed on the thermoelectric element **15** generates a temperature difference in both ends of the thermoelectric element **15** and is discharged along the shared ground electrode **17** disposed on the thermoelectric element **15** via the ASIC **11***a*.

[0084] When the shared ground electrode **17** is disposed in this way, the number of ground electrodes may be reduced to one, and the number of connection lines that accompany with the number of ground electrodes may be reduced, too. Thus, the limitation in the internal space of the ultrasonic probe **110** can be overcome.

[0085] Also, even when the piezoelectric layer **11** and the thermoelectric element **15** are diced, the risk of generating an electrical short is low. In addition, interference that occurs between a plurality of electrode layers is reduced so that uniform sound performance can be maintained.

[0086] FIG. **5**C illustrates a case that the shared signal electrode **16** as well as the shared ground electrode **17** are provided, unlike in FIG. **5**B. Since the shared signal electrode **16** is disposed on the bottom surface of the thermoelectric element **15**, the bottom surface of the thermoelectric element **15** may be a heat dissipation plate, and a top surface of the thermoelectric element **15** may be a heat absorption plate.

[0087] If a current is applied along the shared signal electrode **16**, a current flows from the heat dissipation plate to the heat absorption plate and generates a temperature difference in both ends of the thermoelectric element **15**. Also, the current is transferred from the thermoelectric element **15** to the ASIC **11***a*, is transferred again to the piezoelectric layer **11**, and vibrates the piezoelectric layer **11**. The current that is transmitted to the piezoelectric layer **11** is discharged along the shared ground electrode **17** disposed on the piezoelectric layer **11**.

[0088] Unlike in FIGS. **5**A through **5**C, FIGS. **5**D and **5**E illustrate various embodiments of the ultrasonic probe **110** in which the thermoelectric element **15** makes surface contact with the bottom surface of the piezoelectric layer **11** and the ASIC **11***a* makes surface contact with the bottom surface of the thermoelectric element **15**. Since the current controlled by the ASIC **11***a* may be transferred to the piezoelectric layer **11** via the thermoelectric element **15**, this embodiment may be implemented.

[0089] FIG. **5**D illustrates the ultrasonic probe **110** including the shared ground electrode, in accordance with another embodiment of the present invention. The signal electrode **16***a* for the piezoelectric layer **11** may be disposed on the ASIC **11***a*, and a current may be supplied via the signal electrode **16***a* for the piezoelectric layer **11**. The supplied current may be transferred to the piezoelectric layer **11** via the thermoelectric element **15**, and the piezoelectric layer **11** may vibrate due to the transferred current and may generate ultrasonic waves. The current that vibrates the piezoelectric layer **11** may be discharged through the shared ground electrode **17** disposed on the piezoelectric layer **11**.

[0090] Also, the signal electrode **16***b* for the thermoelectric element **15** may be disposed on the bottom surface of the thermoelectric element **15**. Thus, the bottom surface of the thermoelectric element **15** may be a heat dissipation plate that heats a contact surface between the piezoelectric layer **11** and the thermoelectric element **15**, and the top surface of the thermoelectric element **15** may be a heat absorption plate that cools the contact surface between the piezoelectric layer **11** an the thermoelectric element **15**. The current supplied through the signal electrode **16***b* for the thermoelectric element **15** may flow from the heat dissipation plate to the heat absorption plate and may generate a temperature difference in both ends of the thermoelectric element **15**. The current that flows through the heat absorption plate may flow along the piezoelectric layer **11** and may be discharged along the shared ground electrode **17**.

[0091] FIG. **5**D is the same as FIG. **5**B in that the number of ground electrodes is reduced to one and the weight or volume of the ultrasonic probe **110** may be reduced, unlike in FIG. **5**A.

[0092] FIG. **5**E illustrates the ultrasonic probe **110** including the shared ground electrode and the shared signal electrode, in accordance with still another embodiment of the present invention. The shared signal electrode **16** may be disposed on the ASIC **11***a*, and a current that controls the thermoelectric element **15** and the piezoelectric layer **11** may be supplied through the shared signal electrode **16**. Also, the shared ground electrode **17** may be disposed on the piezoelectric layer **11**, and the supplied current may be discharged through the shared ground electrode **17**.

[0093] Like in FIG. **5**C, the number of electrodes is reduced to two, and there is no problem of the limitation in the internal space of the ultrasonic probe **110**. Also, even when the piezoelectric layer **11** and the thermoelectric element **15** are diced, the risk of generating an electrical short is low. In addition, interference that occurs between a plurality of electrode layers is reduced so that sound performance can be maintained.

[0094] The ultrasonic probe **110** illustrated in FIGS. **2**A and **2**B, FIG. **3**, FIGS. **4**A through **4**C, and FIGS. **5**A through **5**E is a one-dimensional arrangement ultrasonic probe **110**. However, even when the transducer device is arranged in a two-dimensional manner, the temperature of the piezoelectric layer **11** may be controlled through the thermoelectric element **15**.

[0095] FIGS. **6**A and **6**B illustrate ultrasonic probes in which the piezoelectric layer **11** is diced, in accordance with other embodiments of the present invention. Arrows in FIGS. **6**A and **6**B mean a direction in which a current flows.

[0096] Even when the piezoelectric layer **11** is diced into a plurality of channels, temperature of the piezoelectric layer **11** may be controlled using the thermoelectric element **15**. In detail, the piezoelectric layer **11** may be diced into and may include one or more piezoelectric channels. In this case, the piezoelectric layer **11** needs to be maintained at an appropriate temperature at which each piezoelectric channel operates normally. To this end, the thermoelectric element **15** including one or more thermoelectric channels may contact the piezoelectric layer **11**. In particular, the thermoelectric element **15** may be diced into one or more thermoelectric channels, and each piezoelectric channel may contact each thermoelectric channel. Thus, temperature of each piezoelectric channel may be controlled by each thermoelectric channel.

[0097] FIG. **6**A illustrates the ultrasonic probe **110** in which the thermoelectric element **15** makes surface contact with the piezoelectric layer **11** diced into one or more channels, in accordance with an embodiment of the present invention. Like in FIG. **6**A, since the piezoelectric layer **11** includes one or more piezoelectric channels, the thermoelectric element **15** needs to be provided to contact each piezoelectric channel. To this end, the thermoelectric element **15** is diced into one or more thermoelectric channels and is provided to make surface contact with the piezoelectric layer **11**.

[0098] FIG. **6**B illustrates the ultrasonic probe **110** in which the ASIC **11***a* makes surface contact with the piezoelectric layer **11** diced into one or more channels and the diced thermoelectric element **15** makes surface contact with the ASIC **11***a*, in accordance with another embodiment of the present invention. Even when the ASIC **11***a* makes surface contact with the piezoelectric layer **11**, the thermoelectric element **15** diced in the same manner as FIG. **6**A may control temperature of the piezoelectric layer **11**. If each thermoelectric channel makes surface contact with the ASIC **11***a* so as to maintain temperature of each piezoelectric channel that makes surface contact with the ASIC **11***a*, heat exchange between the piezoelectric channel and the thermoelectric channel may be performed by the ASIC **11***a*.

[0099] When the piezoelectric layer **11** is diced into one or more piezoelectric channels, the thermoelectric element **15** may be a thin film type thermoelectric element **15** so that the thermoelectric element **15** can be diced into one or more thermoelectric channels.

[0100] FIG. **7** is a control block diagram of an ultrasonic imaging apparatus including an ultrasonic probe in which a thermoelectric element is disposed, in accordance with an embodiment of the present invention.

[0101] The ultrasonic probe **110** may include the piezoelectric layer **11** that vibrates and generates ultrasonic waves, the thermoelectric element **15** that controls temperature of the piezoelectric layer **11**, and a temperature sensor **20** that senses the temperature of the piezoelectric layer **11**.

[0102] When the temperature of the piezoelectric layer **11** rises due to its vibration or decreases in an extremely low temperature environment, the piezoelectric layer may not operate normally. Thus, the temperature of the piezoelectric layer **11** needs to be maintained at an appropriate level.

[0103] To this end, the thermoelectric element **15** may contact one surface of the piezoelectric layer **11** or may make surface contact with the piezoelectric layer **11** and may contract one surface of the ASIC **11***a* that transfers a current. If a current is supplied to the thermoelectric element **15**, a temperature difference is generated in both ends of the thermoelectric element **15**, and thus, temperature of the piezoelectric layer **11** may be controlled using the temperature difference.

[0104] In detail, the thermoelectric element **15** may include a heat dissipation plate that dissipates heat toward a contact surface between the piezoelectric layer **11** and the thermoelectric element **15** and heats the contact surface, and a heat absorption plate that absorbs heat of the contact surface and cools the contact surface. The heat dissipation plate or the heat absorption plate contacts the piezoelectric layer **11** in consideration of an environment in which ultrasonic diagnosis is performed, so that the piezoelectric layer **11** may be heated or cooled.

[0105] The temperature sensor **20** may be disposed at an inner side of a housing and may sense the temperature of the piezoelectric layer **11**. To this end, the temperature sensor **20** may be disposed to contact the piezoelectric layer **11**. If it is determined that the temperature sensor **20** senses the temperature of the piezoelectric layer **11** and determines that the piezoelectric layer **11** is at a predetermined temperature or more or less, the result of determination may be transmitted to a controller **170** provided on the body **100**.

[0106] The controller **170** may receive the result of sensing temperature from the temperature sensor **20** and may control a supply current supplied to the thermoelectric element **15** based on the result of sensing temperature. Since it is determined that temperature of the piezoelectric layer **11** is at an appropriate level or more or less, the controller **170** may control the ultrasonic imaging apparatus to supply a current to the thermoelectric element **15** and to cool or heat the piezoelectric layer **11**. The controller **170** may include a processor and may be implemented with hardware.

[0107] In the ultrasonic probe **110** and the ultrasonic imaging apparatus including the same according to the one or more embodiments of the present invention, the piezoelectric layer **11** disposed in the ultrasonic probe **110** and the thermoelectric element **15** may make surface contact with each other directly or through the ASIC **11***a* so that the temperature of the piezoelectric layer **11** can be maintained in an optimum state. Accordingly, smooth ultrasonic diagnosis can be performed, and a patient's safety can be maintained.

[0108] As described above, in an ultrasonic probe and an ultrasonic imaging apparatus having the same according to the one or more embodiments of the present invention, a piezoelectric layer is heated or cooled using a thermoelectric element so that an inner side of the ultrasonic probe can be always maintained at an appropriate temperature.

[0109] In addition, an internal structure of the ultrasonic probe can be simplified by integrating electrodes of the thermoelectric element with electrodes of the piezoelectric layer.

[0110] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An ultrasonic probe comprising:
- a piezoelectric layer that vibrates and generates ultrasonic waves if a current is supplied to the piezoelectric layer; and
- a thermoelectric element that contacts one surface of the piezoelectric layer and controls temperature of the piezoelectric layer if a current is supplied to the thermoelectric element.

2. The ultrasonic probe of claim **1**, wherein the thermoelectric element comprises:
- a heat dissipation plate that is disposed on one surface of the thermoelectric element and dissipates heat toward a contact surface between the piezoelectric layer and the thermoelectric element; and
- a heat absorption plate that is disposed at an opposite side to the heat dissipation plate and absorbs heat of the contact surface.

3. The ultrasonic probe of claim **2**, wherein the thermoelectric element contacts the piezoelectric layer through the heat dissipation plate and heats the piezoelectric layer.

4. The ultrasonic probe of claim **2**, wherein the thermoelectric element contacts the piezoelectric layer through the heat absorption plate and cools the piezoelectric layer.

5. The ultrasonic probe of claim **1**, wherein the piezoelectric layer and the thermoelectric element share a signal electrode through which a current is supplied to the piezoelectric layer and the thermoelectric element, respectively.

6. The ultrasonic probe of claim **1**, wherein the piezoelectric layer and the thermoelectric element share a ground electrode.

7. The ultrasonic probe of claim **1**, wherein, when the piezoelectric layer comprises one or more piezoelectric channels, the thermoelectric element comprises one or more thermoelectric channels corresponding to the one or more piezoelectric channels.

8. An ultrasonic probe comprising:
- a piezoelectric layer that vibrates and generates ultrasonic waves if a current is supplied to the piezoelectric layer;
- an application specific integrated circuit (ASIC) that transfers the current to the piezoelectric layer; and
- a thermoelectric element that contacts one surface of the ASIC and controls temperature of the piezoelectric layer if a current is supplied to the thermoelectric element.

9. The ultrasonic probe of claim **8**, wherein the thermoelectric element comprises:
- a heat dissipation plate that is disposed on one surface of the thermoelectric element and dissipates heat toward a contact surface between the piezoelectric layer and the thermoelectric element; and
- a heat absorption plate that is disposed at an opposite side to the heat dissipation plate and absorbs heat of the contact surface.

10. The ultrasonic probe of claim **8**, wherein the piezoelectric layer and the thermoelectric element share a signal electrode through which a current is supplied to the piezoelectric layer and the thermoelectric element, respectively.

11. The ultrasonic probe of claim **8**, wherein the piezoelectric layer and the thermoelectric element share a ground electrode.

12. An ultrasonic imaging apparatus comprising:
- an ultrasonic probe comprising a piezoelectric layer that vibrates and generates ultrasonic waves, a thermoelectric element that contacts one surface of the piezoelectric layer and controls temperature of the piezoelectric layer according to a supplied current, and a temperature sensor that senses the temperature of the piezoelectric layer; and
- a controller that controls the supplied current based on the sensed temperature.

13. An ultrasonic imaging apparatus comprising:
- an ultrasonic probe comprising a piezoelectric layer that vibrates and generates ultrasonic waves, an application specific integrated circuit (ASIC) that transfers a current to the piezoelectric layer, a thermoelectric element that contacts one surface of the ASIC and controls temperature of the piezoelectric layer according to the supplied current, and a temperature sensor that senses the temperature of the piezoelectric layer; and
- a controller that controls the supplied current based on the sensed temperature.

* * * * *

专利名称(译)	超声波探头和超声波成像设备		
公开(公告)号	US20150119718A1	公开(公告)日	2015-04-30
申请号	US14/507681	申请日	2014-10-06
[标]申请(专利权)人(译)	三星麦迪森株式会社		
申请(专利权)人(译)	三星MEDISON CO.，LTD.		
当前申请(专利权)人(译)	三星MEDISON CO.，LTD.		
[标]发明人	JIN GIL JU KWON SUNG DO		
发明人	JIN, GIL JU KWON, SUNG DO		
IPC分类号	A61B8/00 H01L41/113 A61B8/08 B06B1/06		
CPC分类号	A61B8/546 B06B1/0622 A61B8/5223 A61B8/5207 H01L41/113 A61B8/4209 A61B8/4405 A61B8/4444 A61B8/4483		
优先权	1020130129098 2013-10-29 KR		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种使用热电元件控制压电层温度的超声波探头和具有该超声波探头的超声波成像装置。超声波探头包括：压电层，如果向压电层提供电流，则振动并产生超声波;和热电元件，其接触压电层的一个表面，并且如果向热电元件提供电流则控制压电层的温度。