US009322810B2

(12) **United States Patent**
Kim

(10) **Patent No.: US 9,322,810 B2**
(45) **Date of Patent: Apr. 26, 2016**

(54) **ULTRASONIC TRANSDUCERS**

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

(72) Inventor: **Dong-kyun Kim**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 232 days.

(21) Appl. No.: **13/970,821**

(22) Filed: **Aug. 20, 2013**

(65) **Prior Publication Data**

US 2014/0069194 A1 Mar. 13, 2014

(30) **Foreign Application Priority Data**

Sep. 11, 2012 (KR) 10-2012-0100660

(51) **Int. Cl.**

G01N 29/28	(2006.01)
H04R 31/00	(2006.01)
B06B 1/02	(2006.01)
G10K 11/00	(2006.01)
A61B 8/00	(2006.01)

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

CPC ***G01N 29/28*** (2013.01); ***B06B 1/0292*** (2013.01); ***G10K 11/002*** (2013.01); ***H04R 31/006*** (2013.01); *A61B 8/4483* (2013.01); *Y10T 29/49005* (2015.01)

(58) **Field of Classification Search**

CPC G10K 11/002; A61B 8/00; A61B 8/4483; H04R 31/006; H04R 31/00; Y10T 29/49005; G01N 29/28; G01N 2291/106; G01N 29/2406

USPC 73/632, 625, 626, 628, 641; 600/459

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,876,127	B2 *	4/2005	Mitsuoka et al.	310/324
7,257,051	B2	8/2007	Thomenius et al.	
8,008,105	B2	8/2011	Huang	
8,742,646	B2 *	6/2014	Wodnicki	B06B 1/0622 310/334
2003/0052419	A1 *	3/2003	Ujiie et al.	257/787
2004/0190377	A1 *	9/2004	Lewandowski	B06B 1/0292 367/174
2008/0067895	A1	3/2008	Adachi et al.	
2008/0134793	A1	6/2008	Woychik et al.	
2009/0140606	A1 *	6/2009	Huang	B06B 1/0292 310/322
2010/0191108	A1 *	7/2010	Sato	A61B 8/06 600/437
2010/0255623	A1	10/2010	Huang	
2010/0280388	A1	11/2010	Huang	
2011/0071397	A1 *	3/2011	Wodnicki	B06B 1/0629 600/459
2012/0103096	A1 *	5/2012	Kandori	73/632

* cited by examiner

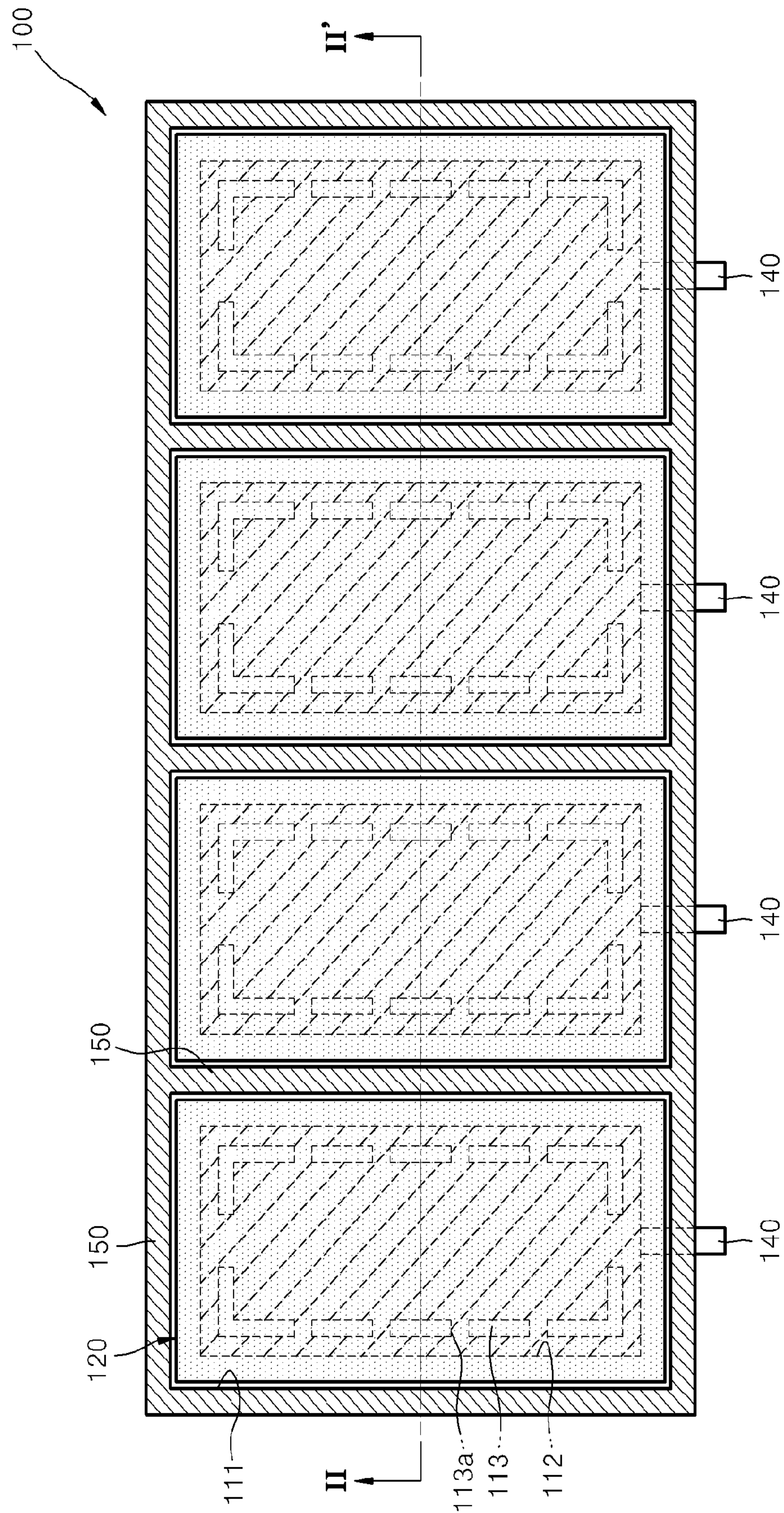
Primary Examiner — Laura Martin
Assistant Examiner — Suman K Nath
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An ultrasonic transducer includes a plurality of transducer modules, a substrate on which each of the plurality of transducer modules is arranged, and a buffer member which buffers the movements of the upper portions of the transducer modules, wherein the buffer member is disposed on the substrate between the plurality of transducer modules and on the substrate outside of the plurality of transducer modules.

25 Claims, 6 Drawing Sheets

FIG. 1



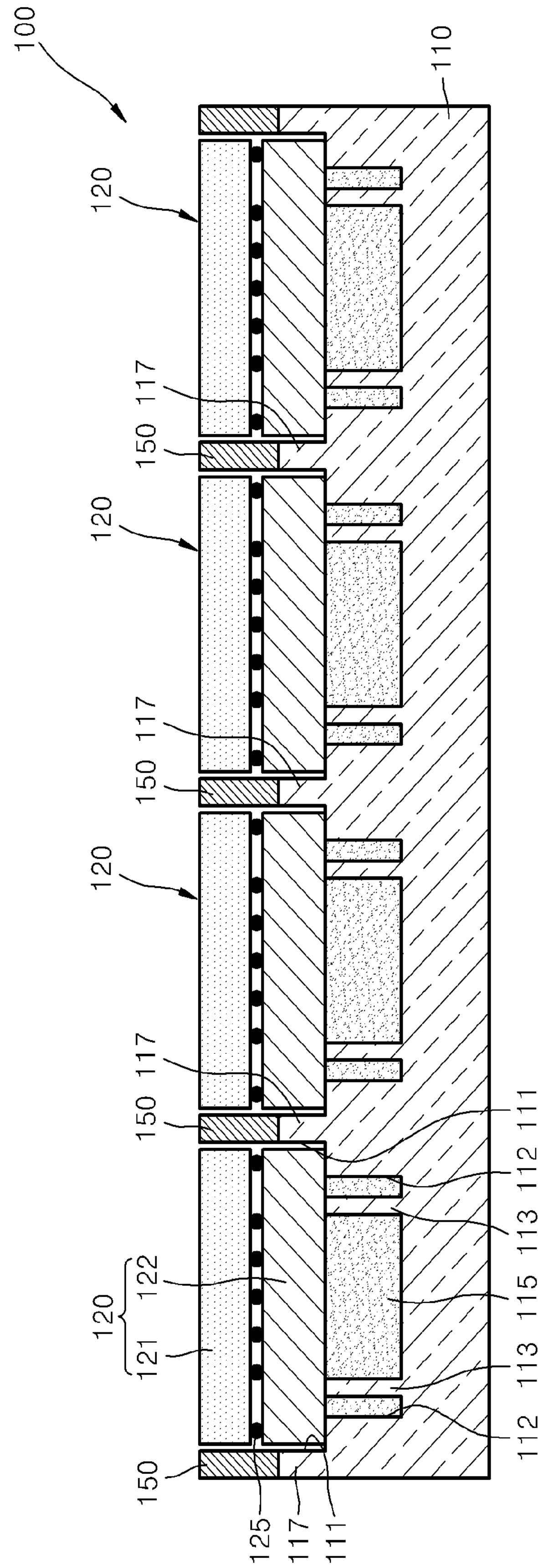


FIG. 2

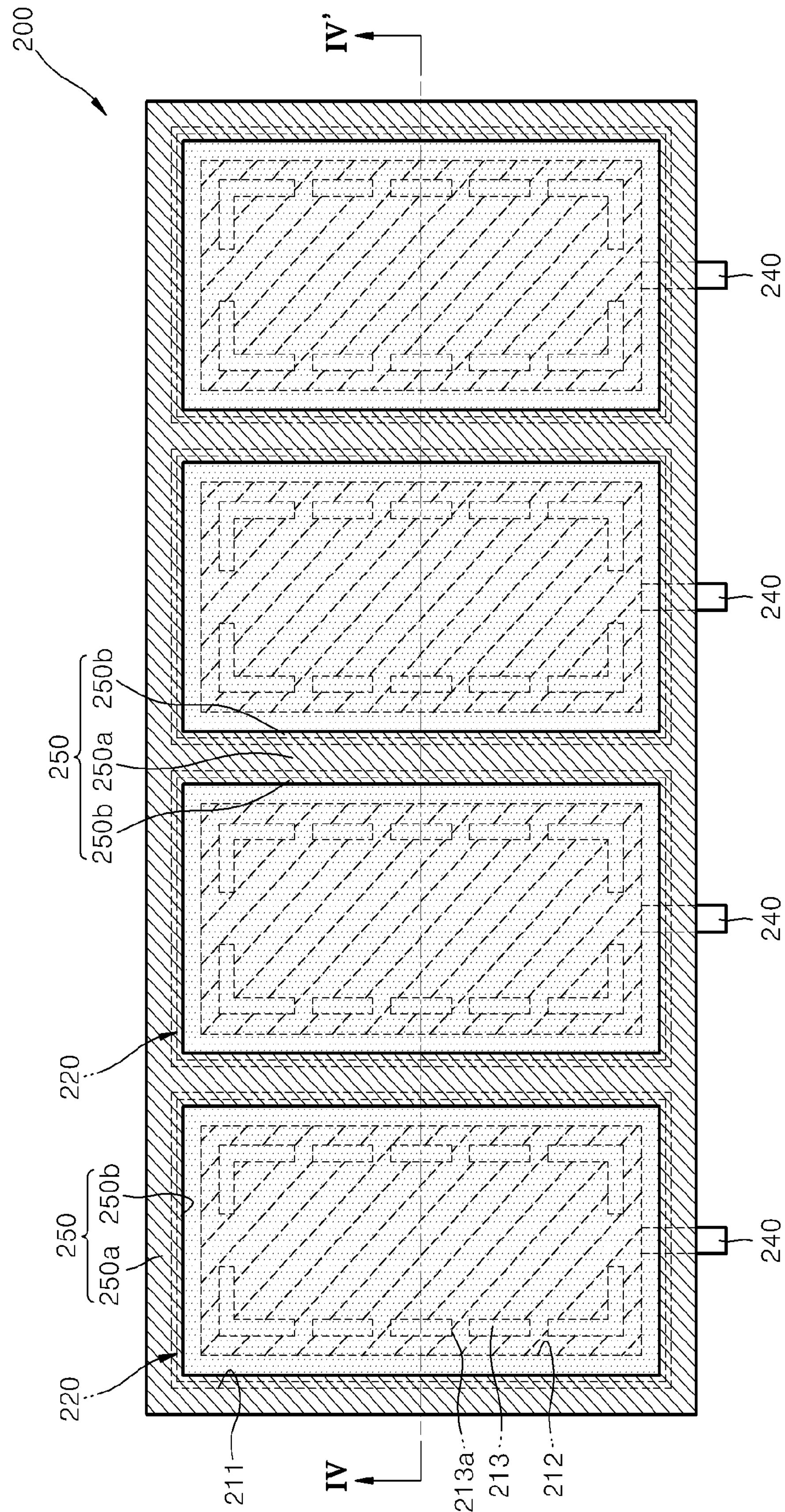
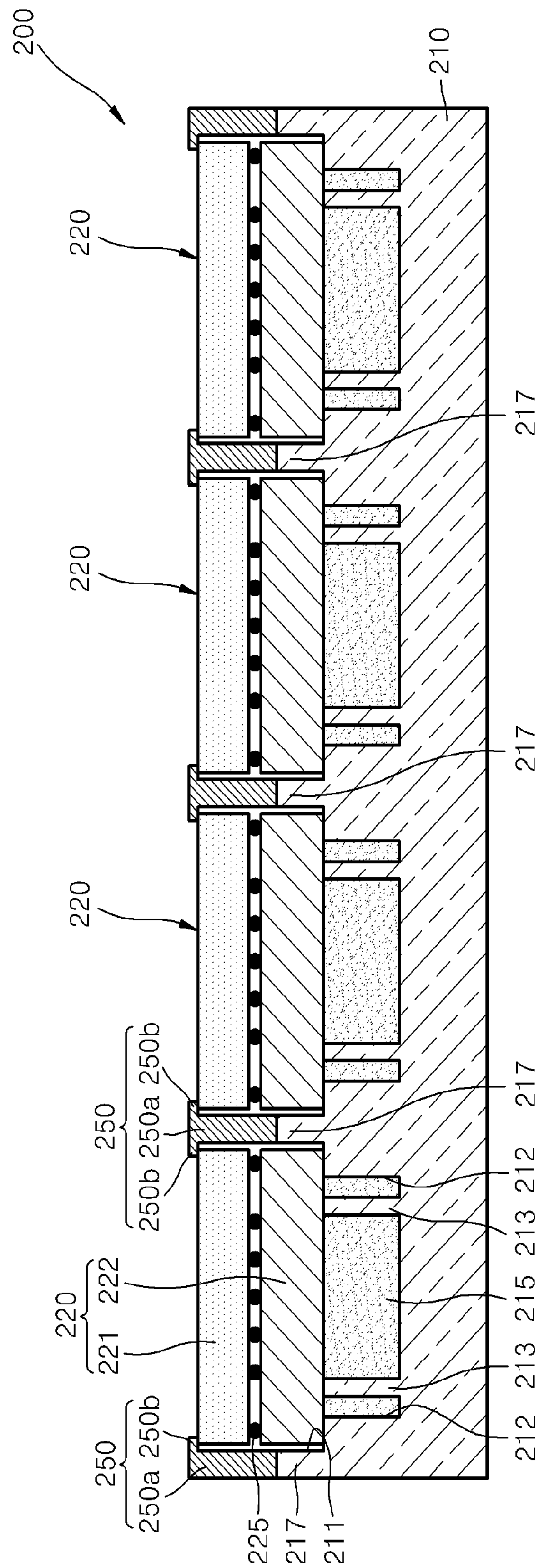


FIG. 3
200
IV'
IV
240
240
240
240
250
250b
250a
250b
250
250b
250a
220
220
211
213a
213
212

FIG. 4



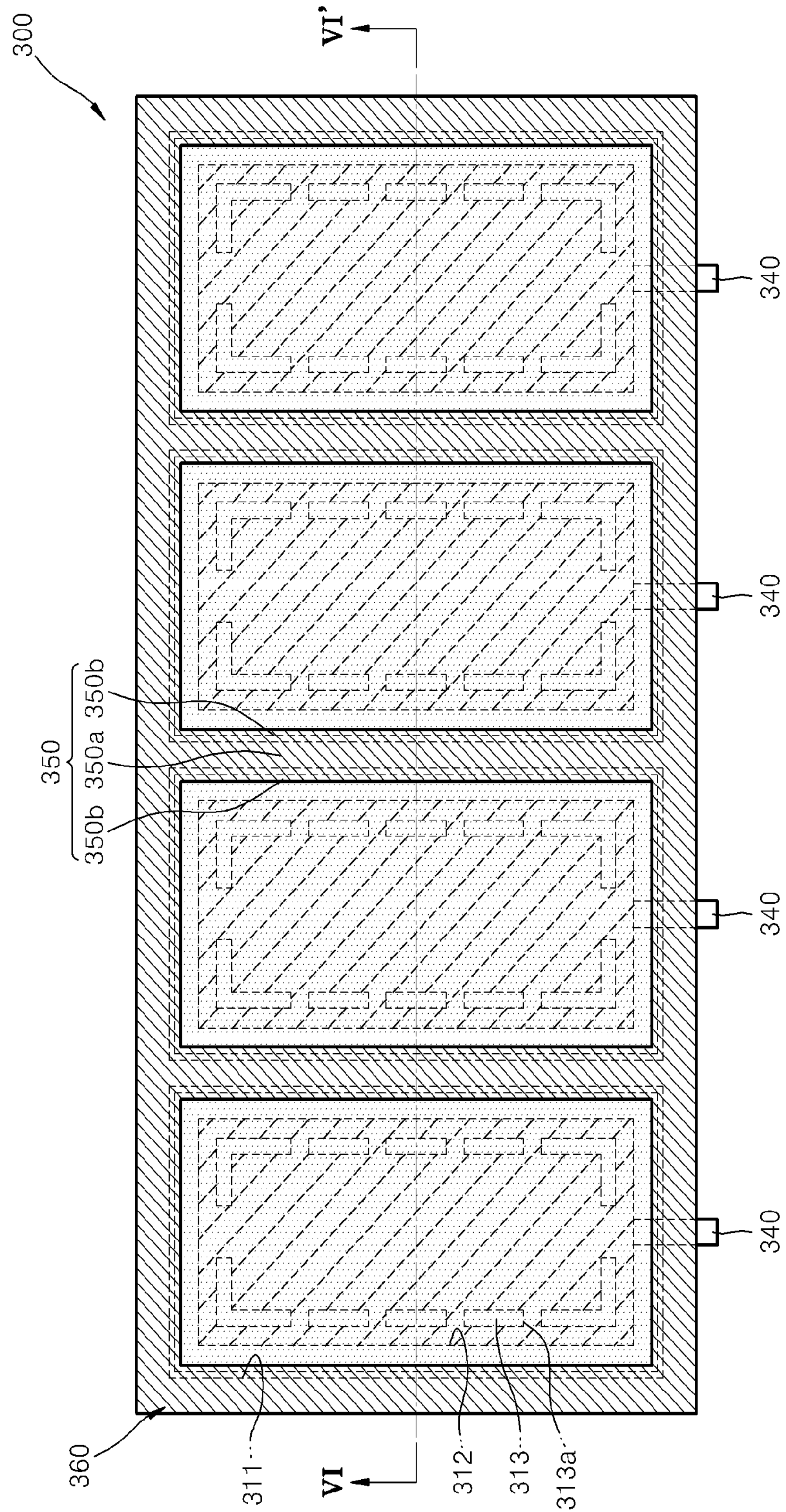


FIG. 5
300
VI'
340
340
340
340
350
350b
350a
350b
360
311
VI
312
313
313a

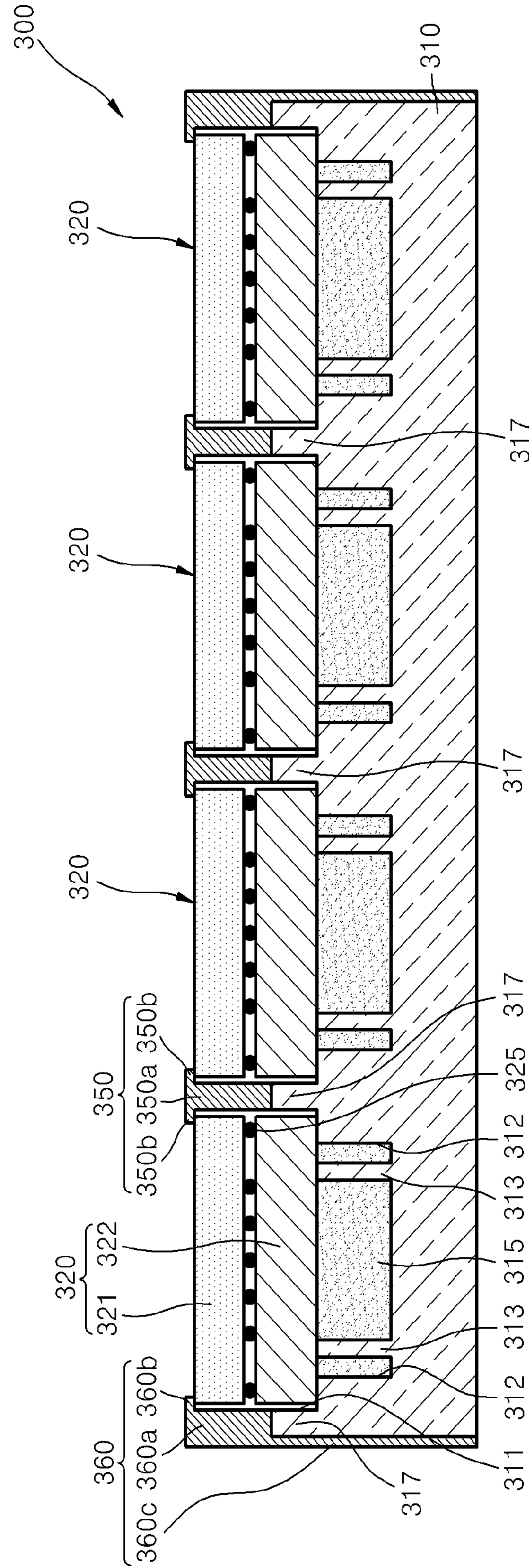


FIG. 6
300
310
320
320
320
320
321
322
317
317
317
317
325
350
350a
350b
350b
312
313
315
313
312
311
360
360a
360b
360c

ULTRASONIC TRANSDUCERS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority from Korean Patent Application No. 10-2012-0100660, filed on Sep. 11, 2012, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field

The present disclosure relates to ultrasonic transducers, and more particularly, to ultrasonic transducers which have a multi-channel capacity and a large area.

2. Description of the Related Art

An equipment which is used for an ultrasonic image diagnosis may include an imaging device which performs signal processing of detected ultrasonic waves that are transmitted and attenuated by scanning a certain part of organisms or that are reflected from boundaries of mediums, each of which has a different acoustic impedance. Such equipment which is used for ultrasonic image diagnosis may include an ultrasonic probe device which transmits ultrasonic waves toward a target object and which receives reflected ultrasonic waves from the target object in order to obtain ultrasonic wave data. The ultrasonic probe device may also include an ultrasonic transducer that converts electrical energy into kinetic energy, or vice versa, within a range of ultrasonic frequencies.

An ultrasonic transducer includes several ultrasonic conversion elements that individually operate to generate one acoustic pulse. However, in order to obtain a high-resolution ultrasound image, the ultrasonic transducer with a multi-channel capacity and a large area which includes a large number of ultrasonic transducer elements is necessary. When this type of ultrasonic transducer is formed in an integral configuration, a main drawback is a falling manufacturing yield. Therefore, in order to solve this problem, a plurality of transducer modules that are large enough to secure a constant yield is manufactured, and the plurality of transducer modules are arranged on a substrate such as a Printed Circuit Board (PCB), and thus, the ultrasonic transducer having a multi-channel capacity and a large area results.

SUMMARY

Provided are ultrasonic transducers which have a multi-channel capacity and a large area.

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

According to an aspect of one or more exemplary embodiments, an ultrasonic transducer includes a plurality of transducers; a substrate on which the plurality of transducers is arranged; and a buffer member which buffers movements of upper portions of the transducers, wherein the buffer member is disposed on the substrate between the plurality of transducers and on the substrate outside of the plurality of transducers.

Each of the plurality of transducers may include an ultrasonic transducer chip and a driver chip which is arranged underneath the ultrasonic transducer chip. Herein, the ultrasonic transducer chip may include a capacitive micromachined ultrasonic transducer chip, and the driver chip may include an application-specific integrated circuit (ASIC) chip.

The substrate may include a plurality of loaders in which the plurality of transducers are loaded, a plurality of adhesive parts which are arranged underneath the plurality of loaders such that top surfaces of the plurality of adhesive parts are adhered to undersurfaces of the plurality of transducers, and a support part which protrudes between the plurality of loaders and outside of the plurality of loaders. The support part may support the driver chips by being set to a lower height than a thickness of one of the plurality of loaders. In addition, the buffer member may buffer movements of the ultrasonic transducer chips because the buffer member is placed on top of the support part, and the buffer member may include at least one polymer-based material.

The buffer member may include at least one of two kinds of buffer members. One kind includes a first buffer part which is arranged on a side of at least one ultrasonic transducer chip, and the other kind includes a second buffer part which extends from the first buffer part toward an upper surface of at least one of the ultrasonic transducer chips.

The buffer member may include a first buffer member which is arranged between the ultrasonic transducer chips and a second buffer member which is arranged on an outside of the ultrasonic transducer chips. Herein, the first buffer member may include a first buffer part which is arranged on a side of at least one of the ultrasonic transducer chips and a second buffer part which extends from the first buffer part toward an upper surface of at least one of the ultrasonic transducer chips. In addition, the second buffer member may include a first buffer part which is arranged on a side of at least one ultrasonic transducer chip, a second buffer part which extends from the first buffer part toward an upper surface of at least one of the ultrasonic transducer chips, and a third buffer part which extends from the first buffer part toward an outside of the substrate.

One of the plurality of loaders may have a width which is wider than a width of a corresponding one of the plurality of transducers, and one of the plurality of adhesive parts may have a width which is narrower than the width of at least one of the plurality of loaders. The plurality of adhesive parts may be filled with adhesive materials. A plurality of out ports which connect the plurality of adhesive parts to an outside of the substrate may be formed in the substrate.

With respect to the plurality of adhesive parts, protrusions that protrude from a bottom of one of the plurality of adhesive parts may be formed. A top surface of at least one of the protrusions may adhere to an undersurface of at least one of the plurality of transducers. At least one of the protrusions may be integrally formed with the substrate. In addition, at least one of the protrusions may include a plurality of protrusions that are spaced at a predetermined spacing.

The substrate may include at least one of silicon, a glass, and a polymer-based material. The transducers may be arranged on the substrate in an m×n array, wherein each of m and n is a natural number.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** is a schematic view which illustrates an ultrasonic transducer, according to an exemplary embodiment;

FIG. **2** is a cross-sectional view which illustrates an ultrasonic transducer that is cut along the lines II-II' of FIG. **1**;

FIG. **3** is a schematic view which illustrates an ultrasonic transducer, according to an exemplary embodiment;

FIG. 4 is a cross-sectional view which illustrates an ultrasonic transducer that is cut along the lines IV-IV' of FIG. 3;

FIG. 5 is a schematic view which illustrates an ultrasonic transducer, according to an exemplary embodiment; and

FIG. 6 is cross-sectional view which illustrates an ultrasonic transducer that is cut along the lines VI-VI' of FIG. 5.

DETAILED DESCRIPTION

Reference will now be made in detail to exemplary embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. In this regard, the present exemplary embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the exemplary embodiments are merely described below, by referring to the figures, to explain aspects of the present disclosure. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

FIG. 1 is a schematic view which illustrates an ultrasonic transducer, according to an exemplary embodiment. FIG. 2 is a cross-sectional view which illustrates an ultrasonic transducer that is cut along the lines II-II' of FIG. 1.

Referring to FIGS. 1 and 2, an ultrasonic transducer **100** includes a plurality of transducer modules **120**, a substrate **110** on which the plurality of transducer modules **120** is arranged, and a buffer member **150** which is arranged on the substrate **110** and which buffers movements of upper portions of the transducer modules **120**. FIGS. 1 and 2 illustrate the ultrasonic transducer **100** as including four transducer modules **120** that are arranged on the substrate **110** in a 1×4 array. However, this arrangement is merely one example, and thus, the ultrasonic transducer **100** may include a varying number of the transducer modules **120** in various types of array configurations. Herein, the varying number of the transducer modules **120** may be arranged on the substrate **110** in an m×n array, wherein each of m and n is a natural numbers, in any of various configurations.

Each of the plurality of transducer modules **120** may include an ultrasonic transducer chip **121** and a driver chip **122** that is arranged underneath the ultrasonic transducer chip **121** in order to operate the ultrasonic transducer chip **121**. In particular, the ultrasonic transducer chip **121** includes a plurality of ultrasonic conversion elements (not shown) that individually operate to generate one acoustic pulse. A capacitive micromachined ultrasonic transducer (CMUT) chip may be used as the ultrasonic transducer chip **121**, and an application specific integrated circuit (ASIC) chip may be used as the driver chip **122**. The ultrasonic transducer chip **121** may be deposited on top of the driver chip **122** by performing a flip chip bonding process. A plurality of bonding balls **125** which are used for performing the flip chip bonding process may be arranged between the ultrasonic transducer chip **121** and the driver chip **122**. In an exemplary embodiment, the plurality of bonding balls **125** may be placed at irregular spacing intervals in order to facilitate a wiring of a bias signal line and a wiring of a pulse signal line.

The substrate **110** includes a plurality of loaders **111** within which the plurality of transducer modules **120** is loaded and a plurality of adhesive parts **112** which is arranged underneath the plurality of loaders **111**. The substrate **100** may include, for example, silicon, glass, and/or a polymer-based material. However, this is merely one example, and thus, the substrate **110** may include a variety of materials in addition to the materials described above. The substrate **110**, including the plurality of loaders **111** and the plurality of adhesive parts **112**, may be manufactured by using a method of semiconductor processing or imprinting. When the method of semiconductor processing is used, positioning errors relating to the plurality of loaders **111** and adhesive parts **112** may be reduced to within several μm, and accordingly, the plurality of transducer modules **120** that is positioned on the plurality of loaders **111** may be uniformly arranged by adhering to the plurality of adhesive parts **112**. Alternatively, when the method of imprinting is used on a silicon substrate, for example, the substrate **110** may be formed of a polymer-based material in order to save production costs and time.

The plurality of loaders **111** is formed on the substrate **110** in correspondence with a number of transducer modules **120** corresponding thereto. The plurality of loaders **111** may be formed at regular spacing intervals (e.g., 20 μm) on the substrate **110**. Herein, FIGS. 1 and 2 illustrate the plurality of loaders **111** which correspond to the plurality of transducer modules **120** which are formed on the substrate **110** in an array of 1×4. However, the arrangement is merely one example, and thus, a varying number of the plurality of loaders **111** may be formed on the substrate **110** in a variety of array configurations, such as an m×n array of m×n, wherein each of m and n is a natural number. Due to the plurality of loaders **111**, each of the transducer modules **120** may be arranged uniformly in a particular direction. Accordingly, the accuracy of the ultrasonic waves may be increased by controlling directions of transmission/reception of the ultrasonic waves in the plurality of transducer modules **120**.

The plurality of loaders **111** may be formed in correspondence with the plurality of transducer modules **120**. The plurality of loaders **111** may be formed to a depth of, for example, dozens μm to hundreds μm. The plurality of loaders **111** may be formed with the same depth, and in this case, the plurality of modules **120** which are arranged on the plurality of loaders **111** may be placed at the same relative height with respect to each other. Accordingly, each of the plurality of transducer modules **120** may transmit ultrasonic waves and receive feedback ultrasonic waves from a target object at the same time. Further, in order to control a timing with respect to the transmission/reception of the ultrasonic waves in each of the plurality of transducer modules **120**, each of the plurality of loaders **111** may be individually formed to a different respective depth.

In order to load the plurality of transducer modules **120** in the plurality of loaders **111** easily, at least one of the plurality of loaders **111** may be formed to have a width which is wider than a width of one of the plurality of transducer modules **120**. For example, a width of at least one of the plurality of loaders **111** may be about 10~20 nm wider than the width of one of the plurality of transducer modules **120**, but the width is not limited thereto. When the plurality of transducer modules **120** are loaded in the centers of the plurality of loaders **111**, the inner sides of the plurality of loaders **111** may be spaced at regular spacing intervals with respect to the sides of the plurality of transducer modules **120**. For example, when the width of at least one of the plurality of loaders **111** is about 10 nm wider than the width of one of the plurality of transducer modules **120**, the inner sides of the at least one of the plurality of loaders **111** may be spaced at about 5 nm spacing intervals with respect to the sides of the plurality of transducer modules **120**.

On the substrate **110** that is positioned underneath the plurality of loaders **111**, a plurality of adhesive parts **112** is formed. Herein, the plurality of adhesive parts **112** is formed

in correspondence with the plurality of loaders **111**. Such plurality of adhesive parts **112** serves to fix the plurality of transducer modules **120** on the substrate **110** by adhering upper surfaces of each of the plurality of adhesive parts **112** to undersurfaces of the plurality of transducer modules **120**. To this end, adhesive materials **115** such as, for example, epoxy may be used for filling in the plurality of adhesive parts **112**. The plurality of adhesive parts **112** may be formed to a depth of, for example, dozens of μm to hundreds of μm, but the depth is not limited thereto. The plurality of adhesive parts **112** may be formed with the same depth or with different respective heights. At least one of plurality of adhesive parts **112** may be formed to be narrower than the width of one of the plurality of loaders **111**, but the widths of the adhesive parts are not limited thereto.

In each of the plurality of adhesive parts **112**, protrusions **113** which protrude from a bottom of at least one of the plurality of adhesive parts **112** may be formed. The protrusions **113** may be integrally formed with the substrate **110**. The protrusions **113** may be arranged at regular spacing intervals along an outer part of at least one of the plurality of adhesive parts **112**. However, the arrangement is not limited thereto, and the protrusion **113** may be arranged in various forms. Herein, a height of at least one of the protrusions **113** may be identical to the height of one of the plurality of adhesive parts **112**. Accordingly, top surfaces of each of the protrusions **113** may be in contact with undersurfaces of each of the plurality of transducer modules **120**. Such protrusions **113** reduce a movement of at least one of the plurality of adhesive parts **112** which movement is caused by vibrations that occur during transmission of the ultrasonic waves by each of the plurality of transducer modules **120**, and thus, the plurality of transducer modules **120** may be adhered more stably to the substrate **110**. After loading the plurality of transducer modules **120** into a space inside of the plurality of loaders **111**, followed by attaching the plurality of adhesive parts **112**, the adhesive materials **115** which fill in the plurality of adhesive parts **112** inside of the protrusions **113** may be moved to the plurality of adhesive parts **112** outside of the protrusions **113** via through-holes **113***a* between the protrusions **113** due to the pressure applied by the plurality of transducer modules **120**. Accordingly, an arrangement of the plurality of protrusions **113** in the plurality of adhesive parts **112** has been described above, but it is also possible to construct integral protrusions. In addition, a plurality of out ports **140** which connect of the plurality of adhesive parts **112** to an outside of the substrate **110** may further be arranged in the substrate **110**. Such out ports **140** may be formed in correspondence with each of the plurality of adhesive parts **112**. After loading the plurality of transducer modules **120** into the plurality of loaders **111**, the adhesive materials **115** which fill in the plurality of adhesive parts **112** may be released into the outside of the substrate **110** during a process of attaching to the plurality of adhesive parts **112** via the out ports **140** due to pressure applied by the plurality of transducer modules **120**.

A supporting part **117** (also referred to herein as a support part **117**) protrudes from the substrate **110** between the plurality of loaders **111** and/or from the substrate **110** outside of the plurality of loaders **111**. Such supporting part **117** may be integrally formed with the substrate **110**. The supporting part **117** may support a lower portion of at least one of the plurality of transducer modules **120**. In particular, the supporting part **117** has a lower height than the thickness of at least one of the plurality of transducer modules **120**, and thus, the sides of the driver chips **122** may be supported. The supporting part **117** may be formed with the height of, for example, of dozens μm, but is not limited thereto. The supporting part **117** may be formed with a width which is identical to the spacing between the plurality of loaders **111**, but is not limited thereto, and may be formed with a width which is narrower than the spacing between the plurality of loaders **111**.

On the supporting part **117**, a buffer member **150** is arranged. Herein, the buffer member **150** may support the upper portion of at least one of the plurality of transducer modules **120**. In particular, the buffer member **150** serves to buffer shocks which result from a movement of at least one of the ultrasonic transducer chips **121** that occurs during the operation of the ultrasonic transducer **100**. In general, when the ultrasonic transducer chips **121**, which are attached to the fixed driver chips **122**, are operated at a low frequency, deformation may be caused due to rotation of the in-plane, thereby resulting in a movement in a horizontal direction. When the ultrasonic transducer chips **121** are operated at a high frequency, deformation may be caused due to distortion on the out-of-plane, thereby resulting in a movement in a vertical direction. In addition, when these deformations increase, the ultrasonic transducer chips **121** that are adjacent to each other may collide with each other.

According to an exemplary embodiment, the buffer member **150** is arranged on the sides of the ultrasonic transducer chips **121** on the supporting part **117** in order to buffer a rotation on the in-plane, that is, the movement of the ultrasonic transducer chips **121** that occurs in a horizontal direction during operation, and thus, deformation of the ultrasonic transducer chips **121** may be reduced. Such a buffer member **150** may include a material which is used to buffer shocks. For example, the buffer member **150** may include a polymer-based material such as epoxy, but is not limited thereto. Due to the buffer member **150**, deformation of the ultrasonic transducer chips **121** may be prevented, and accordingly, increased accuracy with respect to ultrasonic transmission and reception become possible. The buffer member **150** may be made by printing a polymer-based material by using a technique such as an imprinting on the supporting part **117** of the substrate **110**, which shortens production time and reduces production cost.

FIG. **3** is a schematic view which illustrates an ultrasonic transducer, according to an exemplary embodiment, and FIG. **4** is a cross-sectional view which illustrates an ultrasonic transducer that is cut along the lines IV-IV' of FIG. **3**. Hereinafter, the present exemplary embodiment is described with respect to a different point of focus from the exemplary embodiments described above.

Referring to FIGS. **3** and **4**, an ultrasonic transducer **200** includes a plurality of transducer modules **220**, a substrate **210** on which the plurality of transducer modules **220** is arranged, a buffer member **250** which is arranged on the substrate **210** and which buffers a movement of an upper portion of at least one of the plurality of transducer modules **220**. The ultrasonic transducer **200** may include a varying number of transducer modules **220**, and the plurality of transducer modules **220** may be variously arranged on the substrate **210**; for example, the plurality of transducer modules **220** may be arranged in an m×n array, wherein each of m and n is a natural number. Each of the plurality of transducer modules **220** may include a driver chip **222** and an ultrasonic transducer chip **221** that is attached to the top of the driver chip **222** via flip chip bonding. A CMUT chip may be used as the ultrasonic transducer chip **221**, and an ASIC chip may be used as the driver chip **222**. In addition, a plurality of bonding balls **225** which are used for performing flip chip bonding may be provided between the ultrasonic transducer chip **221** and the driver chip **222**.

The substrate **210** includes a plurality of loaders **211** within which the plurality of transducer modules **220** are loaded and a plurality of adhesive parts **212** which is arranged underneath the plurality of loaders **211**. The substrate **210** may include, for example, at least one of silicon, glass, and a polymer-based material. The plurality of loaders **211** is formed on the substrate **210**, and the number of loaders **211** depends on the number of the transducer modules. Each of the plurality of loaders **211** may be formed at regular spacing intervals on the substrate **210**. The plurality of loaders **211** may be formed in correspondence with the plurality of transducer modules **220**. For example, each of the plurality of loaders **211** may be formed to a depth of dozens of μm to hundreds of μm. Each of the plurality of loaders **211** also may be formed with the same depth or with different depths with respect to each other. In addition, each of the plurality of loaders **211** may be formed to be wider than the each of the plurality of transducer modules **220**, in order to facilitate loading of each of the plurality of transducer modules **220** in each of the plurality of loaders **211** easily.

In the substrate **210**, which is positioned underneath of the plurality of loaders **211**, the plurality of adhesive parts **212** is formed. Herein, the plurality of adhesive parts **212** is formed in correspondence with each of the plurality of loaders **211**. An adhesive material **215**, such as, for example, epoxy, may be used to fill in the plurality of adhesive parts **212**. Each of the plurality of adhesive parts **212** may be formed to a depth of, for example, dozens of μm to hundreds of μm, but the depth is not limited thereto. Each of the plurality of adhesive parts **212** may have the same depth or different depths with respect to each other. In addition, each of the plurality of adhesive parts **212** may be formed to have a width which is smaller than the width of the plurality of loaders **211**, but the width is not limited thereto. In each of the plurality of adhesive parts **212**, protrusions **213** which protrude from the bottoms of at least one of the plurality of adhesive parts **212** may be arranged. A depth of the protrusions **213** may be the same as a height of at least one of the plurality of adhesive parts **212**. Alternatively, in the plurality of adhesive parts **212**, protrusions that are integrally formed may be provided. Further, in the substrate **210**, a plurality of out ports **240** which connect the plurality of adhesive parts **212** to the outside of the substrate **210** may be arranged.

On the substrate **210**, between the plurality of loaders **211** and outside of the plurality of loaders **211**, a supporting part **217** is arranged in a protruding form. The supporting part **217** may be integrally formed with the substrate **210**. The supporting part **217** may support a lower portion of at least one of the plurality of transducer modules **220**. In particular, the supporting part **217** is arranged with a height which is less than the thickness of at least one of the plurality of transducer modules **220**, and thus, the supporting part **217** may be able to support the driver chips **222**. The supporting part **217** may be formed to a height of, for example, dozens of μm, but the height is not limited thereto. In addition, the supporting part **217** may be formed with a width which is equal to or less than a spacing between the plurality of loaders **211**.

On top of the supporting part **217**, a buffer member **250** is provided. Herein, the buffer member **250** may be able to support the upper portion of at least one of the plurality of transducer modules **220**. The buffer member **250** may include a first buffer part **250*a*** which is positioned on the sides of the ultrasonic transducer chips **221** and a second buffer part **250*b*** which extends from the first buffer part **250*a*** toward the upper surface of at least one of the ultrasonic transducer chips **220**. Herein, the first buffer part **250*a*** may buffer the movements of the ultrasonic transducer chips **220** in a horizontal direction, which result from a rotation on the in-plane that occurs during the operation of the ultrasonic transducer chips **220**. Further, the second buffer part **250*b*** may buffer the movements of the ultrasonic transducer chips **220** in a vertical direction, which result from a distortion on the out-of-plane that occurs during the operation of the ultrasonic transducer chips **220**. Accordingly, the buffer member **250** may reduce a deformation of at least one of the ultrasonic transducer chips **221** which results from rotation on the in-plane and distortion on the out-of-plane. The buffer member **250** may include a polymer-based material, such as, for example, epoxy, but the material is not limited thereto. Therefore, according to the present exemplary embodiment, the buffer member **250** may be able to buffer not only rotation on the in-plane, but also distortion on the out-of-plane; thus, deformation of the ultrasonic transducer chips **221** may be prevented more efficiently, thereby providing a more accurate ultrasonic transmission and/or reception.

FIG. **5** is a schematic view which illustrates an ultrasonic transducer, according to an exemplary embodiment, and FIG. **6** is cross-sectional view which illustrates an ultrasonic transducer that is cut along the lines VI-VI' of FIG. **5**.

Referring to FIGS. **5** and **6**, an ultrasonic transducer **300** includes a plurality of transducer modules **320**, a substrate **310** on which the plurality of transducer modules **320** is arranged, and a buffer member **350** which is arranged on the substrate **310** and which buffers the movements of an upper portion of at least one of the plurality of transducer modules **320**. Each of the plurality of transducer modules **320** may include a driver chip **322** and an ultrasonic transducer chip **321** that is attached to the top of the driver chip **322** via flip chip bonding. A CMUT chip may be used as the ultrasonic transducer chip **321**, and an ASIC chip may be used as the driver chip **322**. In addition, a plurality of bonding balls **325** which are used for flip chip bonding may be provided between at least one ultrasonic transducer chip **321** and at least one corresponding driver chip **322**.

The substrate **310** includes a plurality of loaders **311** within which the plurality of transducer modules **320** is loaded and a plurality of adhesive parts **312** which is arranged underneath the plurality of loaders **311**. Each of the plurality of loaders **311** may be formed with the same depth or with different depths with respect to each other. In addition, each of the plurality of loaders **311** may be formed to have a width which is wider than the width of at least one of the plurality of transducer modules **320**. In the substrate **310** underneath of the plurality of loaders **311**, the plurality of adhesive parts **312** is formed. An adhesive material **315**, such as, for example, epoxy, may be used to fill in the plurality of adhesive parts **312**. Each of the plurality of adhesive parts **312** may have the same depth or a different depth with respect to each other. In addition, each of the plurality of adhesive parts **312** may be formed to have a width which is smaller than the width of at least one of the plurality of loaders **311**, but the width is not limited thereto. In each of the plurality of adhesive parts **312**, protrusions **313** which protrude from the bottoms of the plurality of adhesive parts **312** may be provided. Depth of the protrusions **313** may be the same as a height of each of the plurality of adhesive parts **312**. Further, in the substrate **310**, a plurality of out ports **340** which connect the plurality of adhesive parts **312** to the outside of the substrate **310** may be arranged.

On the substrate **310**, between the plurality of loaders **311** and outside the plurality of loaders **311**, a supporting part **317** is arranged in a protruding form. The supporting part **317** is arranged with a height which is less than the thickness of at least one of the plurality of transducer modules **320**, and thus,

the supporting part **317** may be able to support the driver chips **322**. In addition, the supporting part **317** may be formed with a width which is equal to or less than a spacing between the plurality of loaders **311**.

On top of the supporting part **317**, a buffer member **350** is provided. Herein, the buffer member **350** may be able to support the upper portion of at least one of the plurality of transducer modules **320**. The buffer member **350** includes a first buffer member which is arranged between the ultrasonic transducer chips **320** and a second buffer member **360** which is arranged outside of the ultrasonic transducer chips **320**. The first buffer member **350** may include a first buffer part **350***a* which is positioned on the sides of the ultrasonic transducer chips **320** and a second buffer part **350***b* which extends from the first buffer part **350***a* toward the upper surface of at least one of the ultrasonic transducer chips **320**. Herein, the first buffer part **350***a* may buffer the movements of the ultrasonic transducer chips **320** in a horizontal direction, which result from a rotation on the in-plane that occurs during the operation of the ultrasonic transducer chips **320**. Further, the second buffer part **350***b* may buffer the movements of the ultrasonic transducer chips **320** in a vertical direction, which result from a distortion on the out-of-plane that occurs during the operation of the ultrasonic transducer chips **320**. In addition, the second buffer member **360** may include a first buffer part **360***a* which is positioned on the sides of the ultrasonic transducer chips **320**, a second buffer part **360***b* which extends from the first buffer part **350***a* toward the upper surface of at least one of the ultrasonic transducer chips **320***b*, and a third buffer part **360***c* which extends from the first buffer part **360***a* toward the outside of the substrate **310**. Herein, the first buffer part **360***a* may buffer a rotation on the in-plane of the ultrasonic transducer chips **320**, and the second buffer part **360***b* may buffer a distortion on the out-of-plane of the ultrasonic transducer chips **320**. Therefore, deformation of the ultrasonic transducer chips **320** due to the rotation on the in-plane and distortion on the out-of-plane are reduced, and thus, increased accuracy of ultrasonic transmission and/or reception become possible. According to the present exemplary embodiment, the third buffer part **360***c* is formed to surround the end sides of the substrate **310**, thus, the second buffer member **360** may be more firmly formed on the substrate **310**, as compared to the exemplary embodiment described above.

As described above, the buffer members may be provided between the ultrasonic transducer chips and outside of the ultrasonic transducer chips. The movements of the ultrasonic transducer chips in horizontal and vertical directions that may occur during the operation of the ultrasonic transducer chips may be buffered, and thus, deformation of ultrasonic transducer chips may be prevented. Accordingly, the ultrasonic transducer chips may perform more accurate ultrasonic transmission/reception. Further, buffer members may be prepared on a substrate in a short time at a low cost by forming a polymer-based material by using an imprinting technology.

It should be understood that the exemplary embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each exemplary embodiment should typically be considered as available for other similar features or aspects in other exemplary embodiments.

What is claimed is:

1. An ultrasonic transducer comprising:

a plurality of transducers;

a substrate on which the plurality of transducers is arranged; and

a buffer member which buffers movements of upper portions of the transducers,

wherein the buffer member is disposed on the substrate between adjacent transducers within the plurality of transducers and on the substrate outside of the plurality of transducers.

2. The ultrasonic transducer of claim **1**, wherein each of the plurality of transducers comprises an ultrasonic transducer chip and a driver chip which is arranged underneath the ultrasonic transducer chip.

3. The ultrasonic transducer of claim **2**, wherein the ultrasonic transducer chip comprises a capacitive micromachined ultrasonic transducer chip, and the driver chip comprises an application-specific integrated circuit (ASIC) chip.

4. The ultrasonic transducer of claim **2**, wherein the substrate comprises a plurality of loaders in which the plurality of transducers are loaded, a plurality of adhesive parts which are arranged underneath the plurality of loaders such that top surfaces of the plurality of adhesive parts are adhered to undersurfaces of the plurality of transducers, and a support part which protrudes between the plurality of loaders and outside of the plurality of loaders.

5. The ultrasonic transducer of claim **4**, wherein the support part supports the driver chips.

6. The ultrasonic transducer of claim **5**, wherein the buffer member buffers movements of the ultrasonic transducer chips on a top surface of the support part.

7. The ultrasonic transducer of claim **6**, wherein the buffer member comprises at least one polymer-based material.

8. The ultrasonic transducer of claim **6**, wherein the buffer member comprises a first buffer part which is arranged on a side of at least one of the ultrasonic transducer chips and a second buffer part which extends from the first buffer part toward an upper surface of at least one of the ultrasonic transducer chips.

9. The ultrasonic transducer of claim **6**, wherein the buffer member comprises a first buffer member which is arranged between the ultrasonic transducer chips and a second buffer member which is arranged outside of the ultrasonic transducer chips.

10. The ultrasonic transducer of claim **9**, wherein the first buffer member comprises a first buffer part which is arranged on a side of at least one of the ultrasonic transducer chips and a second buffer part which extends from the first buffer part toward an upper surface of at least one of the ultrasonic transducer chips.

11. The ultrasonic transducer of claim **9**, wherein the second buffer member comprises a first buffer part which is arranged on a side of at least one of the ultrasonic transducer chips, a second buffer part which extends from the first buffer part toward an upper surface of at least one of the ultrasonic transducer chips, and a third buffer part which extends from the first buffer part toward an outside of the substrate.

12. The ultrasonic transducer of claim **4**, wherein one of the plurality of loaders has a width which is wider than a width of a corresponding one of the plurality of transducers, and one of the plurality of adhesive parts has a width which is narrower than the width of at least one of the plurality of loaders.

13. The ultrasonic transducer of claim **4**, wherein the plurality of adhesive parts is filled with adhesive materials.

14. The ultrasonic transducer of claim **13**, wherein a plurality of out ports which connect the plurality of adhesive parts to an outside of the substrate is formed in the substrate.

15. The ultrasonic transducer of claim **4**, wherein at least one of protrusions which protrude from a bottom of one of the plurality of adhesive parts is formed in each of the plurality of adhesive parts.

16. The ultrasonic transducer of claim **15**, wherein at least one of the protrusions comprises a top side which adheres to an undersurface of at least one of the plurality of transducers.

17. The ultrasonic transducer of claim **15**, wherein at least one of the protrusions is integrally formed with the substrate.

18. The ultrasonic transducer of claim **15**, wherein at least one of the protrusions comprises a plurality of protrusions that are spaced at a predetermined spacing.

19. The ultrasonic transducer of claim **1**, wherein the substrate comprises at least one of silicon, a glass, and a polymer-based material.

20. The ultrasonic transducer of claim **1**, wherein the plurality of transducers are arranged on the substrate in an m×n array, wherein each of m and n is a natural number.

21. A method for manufacturing an ultrasonic transducer, the method comprising:

arranging a plurality of transducers on a substrate; and

arranging a buffer member which buffers movements of upper portions of the transducers,

wherein the buffer member is disposed on the substrate between adjacent transducers within the plurality of transducers and on the substrate outside of the plurality of transducers.

22. The method of claim **21**, wherein each of the plurality of transducers comprises an ultrasonic transducer chip and a driver chip which is arranged underneath the ultrasonic transducer chip.

23. The method of claim **22**, wherein the ultrasonic transducer chip comprises a capacitive micromachined ultrasonic transducer chip, and the driver chip comprises an application-specific integrated circuit (ASIC) chip.

24. The method of claim **22**, further comprising:

arranging, on the substrate, a plurality of loaders in which the plurality of transducers are loaded;

arranging, on the substrate, a plurality of adhesive parts which are arranged underneath the plurality of loaders such that top surfaces of the adhesive parts are adhered to undersurfaces of the transducers; and

arranging, on the substrate, a support part which protrudes between the plurality of loaders and outside of the plurality of loaders.

25. The method of claim **24**, wherein the support part supports the driver chips.

* * * * *

patsnap

专利名称(译)	超声波换能器		
公开(公告)号	US9322810	公开(公告)日	2016-04-26
申请号	US13/970821	申请日	2013-08-20
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
[标]发明人	KIM DONG KYUN		
发明人	KIM, DONG-KYUN		
IPC分类号	G01N29/28 B06B1/02 H04R31/00 G10K11/00 A61B8/00		
CPC分类号	G01N29/28 B06B1/0292 G10K11/002 H04R31/006 A61B8/4483 Y10T29/49005		
代理机构(译)	萨格鲁MION，PLLC		
审查员(译)	MARTIN，LAURA		
优先权	1020120100660 2012-09-11 KR		
其他公开文献	US20140069194A1		
外部链接	Espacenet USPTO		

摘要(译)

超声换能器包括多个换能器模块，其上布置有多个换能器模块中的每一个的基板，以及缓冲换能器模块的上部的运动的缓冲构件，其中缓冲构件设置在基板上在多个换能器模块之间和多个换能器模块外部的基板上。