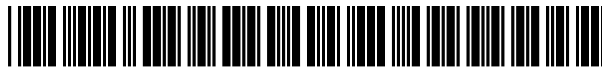

US010561398B2

(12) **United States Patent**
Daloz et al.

(10) **Patent No.: US 10,561,398 B2**
(45) **Date of Patent: Feb. 18, 2020**

(54) **ULTRASOUND TRANSDUCER AND METHOD FOR WAFER LEVEL BACK FACE ATTACHMENT**

(71) Applicant: **General Electric Company**, Schenectady, NY (US)

(72) Inventors: **Flavien Daloz**, Antibes (FR); **Jason Barrett**, Queen Creek, AZ (US); **Edouard Da Cruz**, Nice (FR); **Jean Pierre Malacrida**, Saint Laurent (FR)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 381 days.

(21) Appl. No.: **15/385,671**

(22) Filed: **Dec. 20, 2016**

(65) **Prior Publication Data**

US 2018/0175278 A1 Jun. 21, 2018

(51) **Int. Cl.**

H01L 41/09	(2006.01)
A61B 8/00	(2006.01)
B06B 1/06	(2006.01)
H01L 41/313	(2013.01)
H01L 41/08	(2006.01)
H01L 41/338	(2013.01)

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

CPC ***A61B 8/4483*** (2013.01); ***B06B 1/0644*** (2013.01); ***H01L 41/0815*** (2013.01); ***H01L 41/313*** (2013.01); ***H01L 41/338*** (2013.01)

(58) **Field of Classification Search**

CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,905,007 B2	3/2011	Calisti et al.		
2009/0182233 A1*	7/2009	Wodnicki	G10K 11/345	600/443
2010/0066207 A1*	3/2010	Saito	A61B 8/4281	310/335
2011/0181149 A1*	7/2011	Shikata	B06B 1/0629	310/327
2012/0157853 A1	6/2012	Gelly et al.		
2014/0132114 A1*	5/2014	Fukase	H01L 41/0475	310/322
2014/0375171 A1*	12/2014	Tai	H01L 41/0825	310/341
2015/0266059 A1*	9/2015	Kubo	B06B 1/0622	310/334

OTHER PUBLICATIONS

Daloz, F. et al., "Ultrasound Transducer and Method for Wafer Level Front Face Attachment," U.S. Appl. No. 15/385,620, filed Dec. 20, 2016, 34 pages.

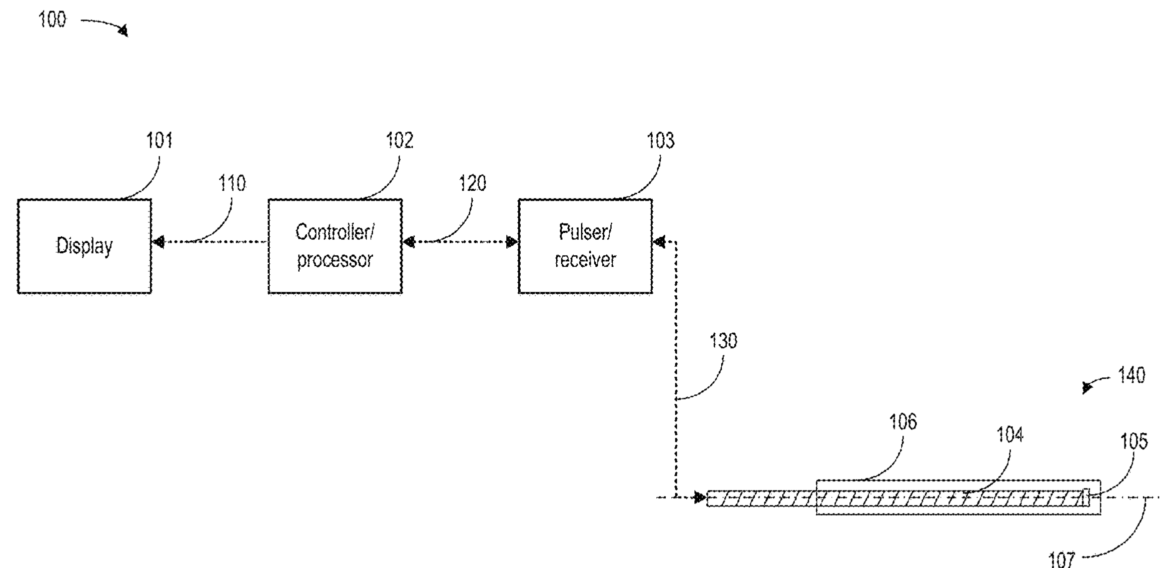
* cited by examiner

Primary Examiner — Bryan P Gordon
(74) *Attorney, Agent, or Firm* — McCoy Russell LLP

(57) **ABSTRACT**

Methods and systems are provided for a single element ultrasound transducer. In one embodiment, the ultrasound transducer comprises a front face, a back face parallel to the front face, a piezoelectric layer having a top surface electrically coupled to the signal pad and a bottom surface electrically coupled to the ground pad. In this way, the transducer can work robustly and may be automatically mounted to an imaging probe.

17 Claims, 10 Drawing Sheets



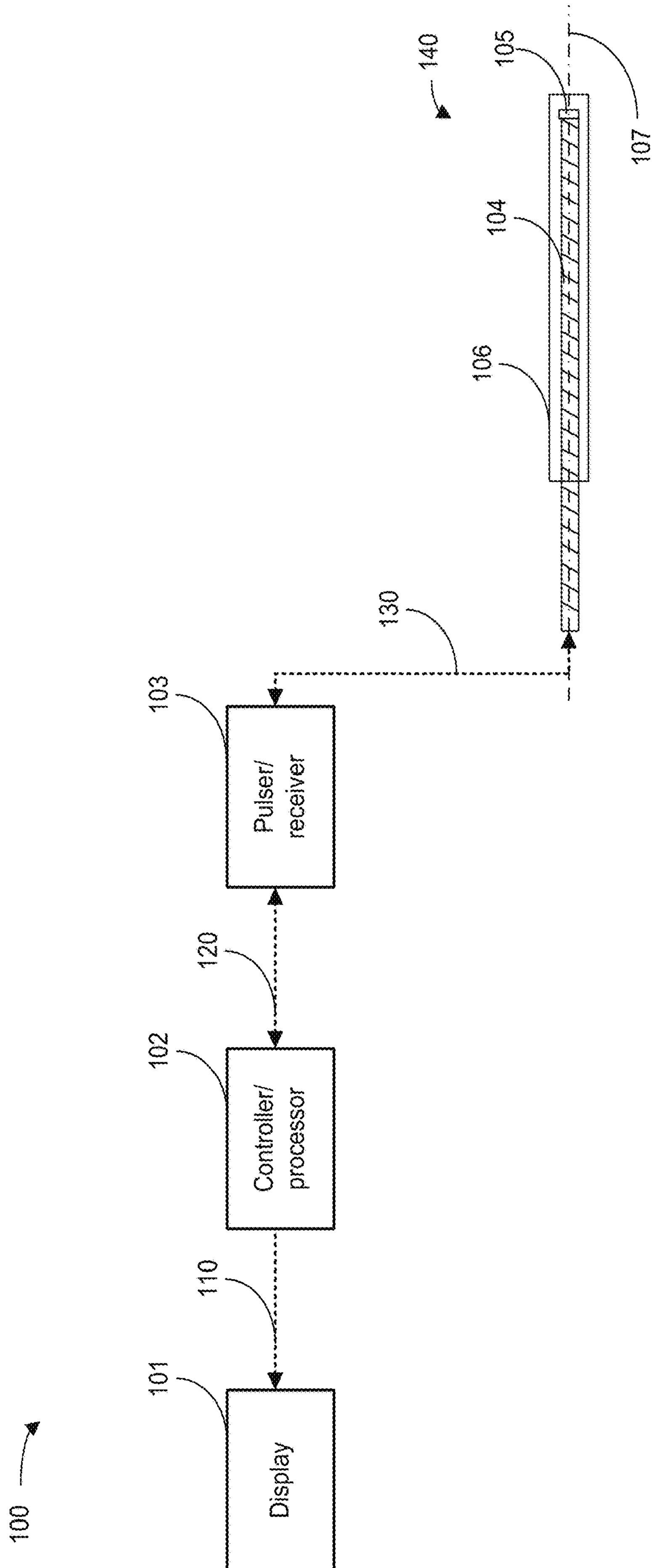


FIG. 1

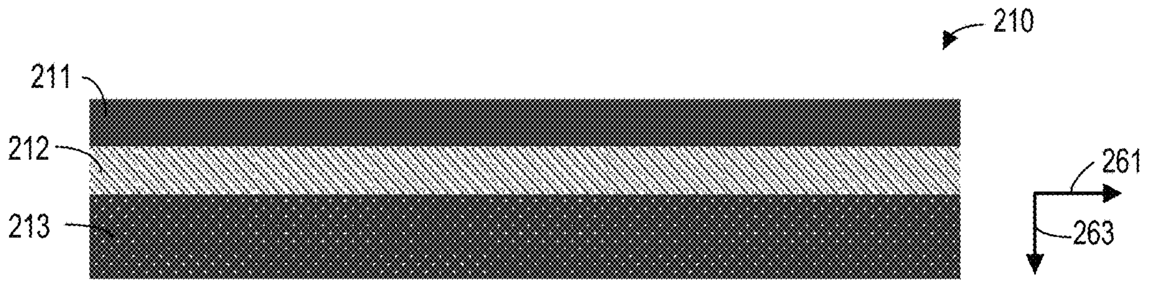


FIG. 2A

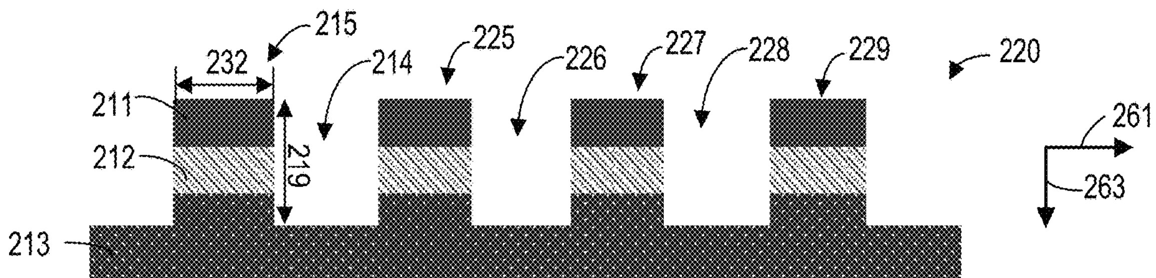


FIG. 2B

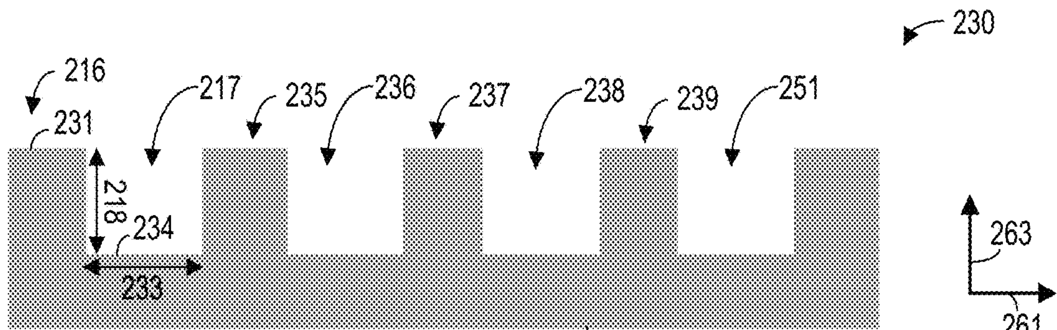


FIG. 2C

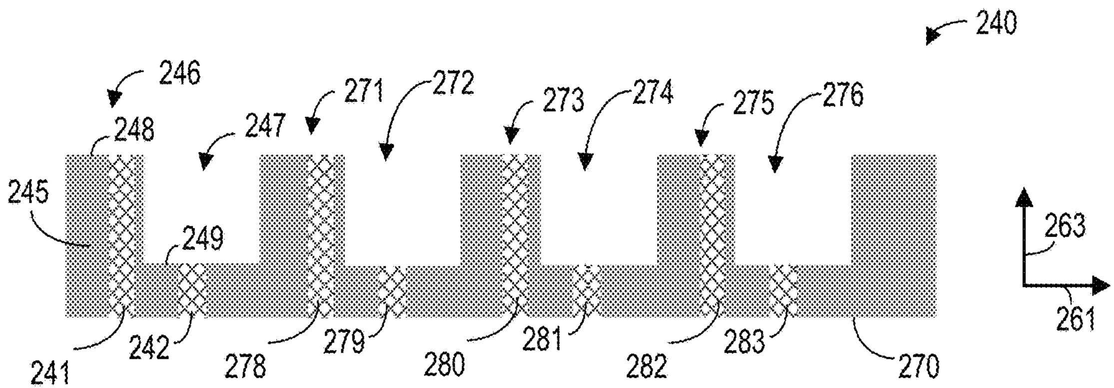


FIG. 2D

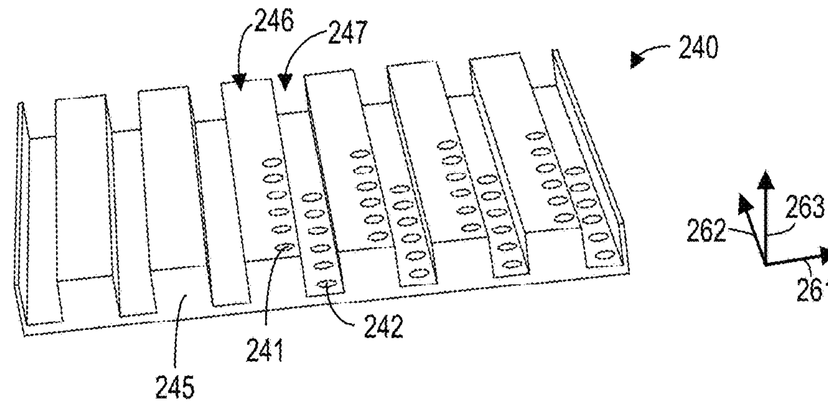


FIG. 3

410
450
213
212
T1
245
263
261
241
242
211
420
212
213
245
T2
263
261
241
242
211
430
431
433
T3
263
261
432
440
213
245
T4
263
261
241
441
242
211
Time

FIG. 4

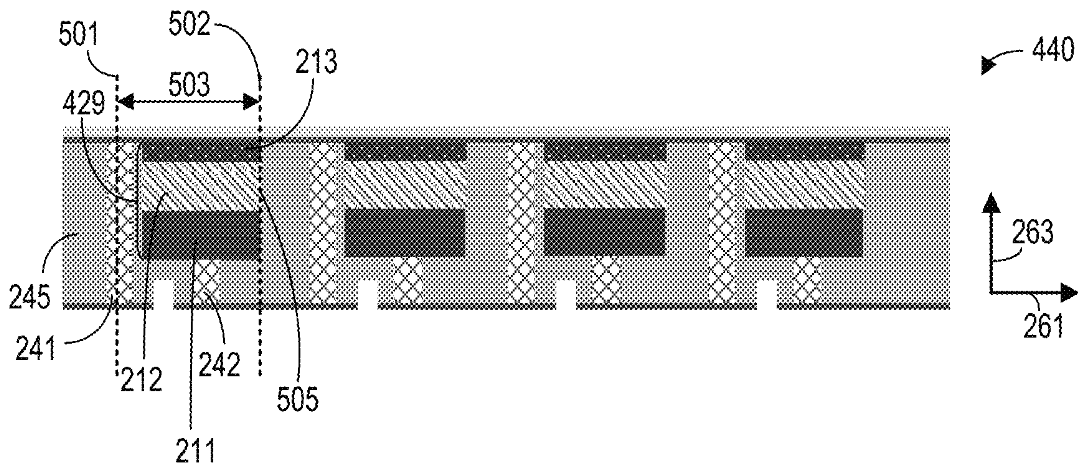


FIG. 5A

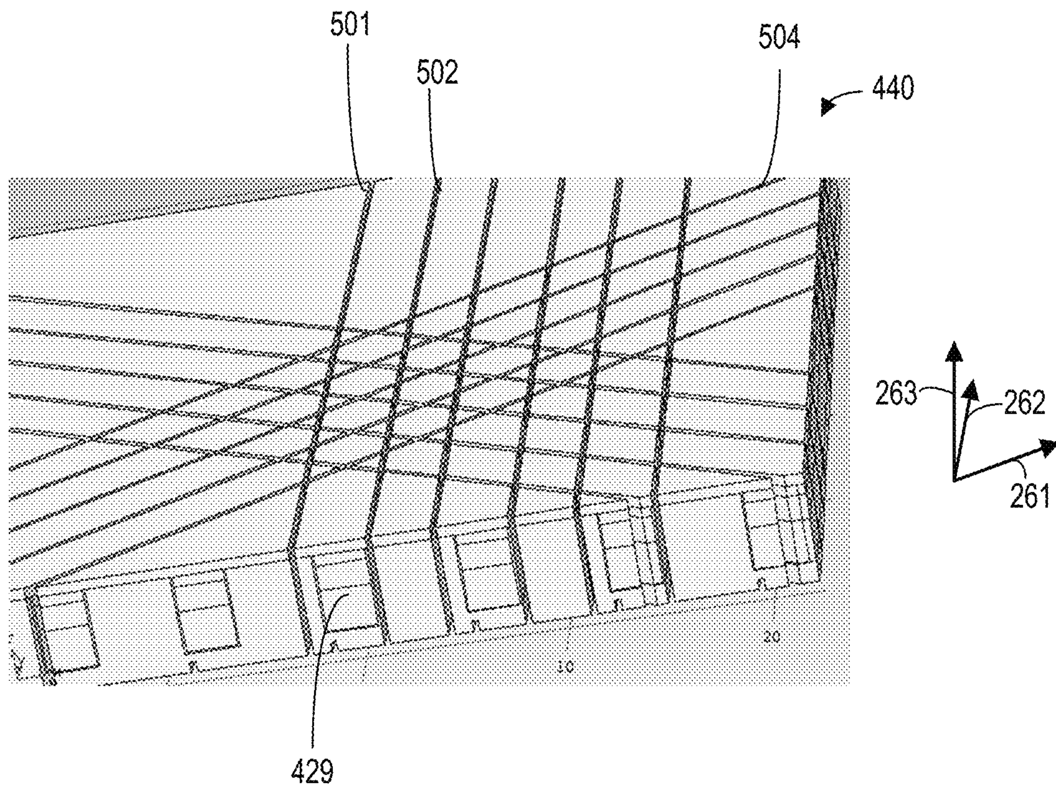


FIG. 5B

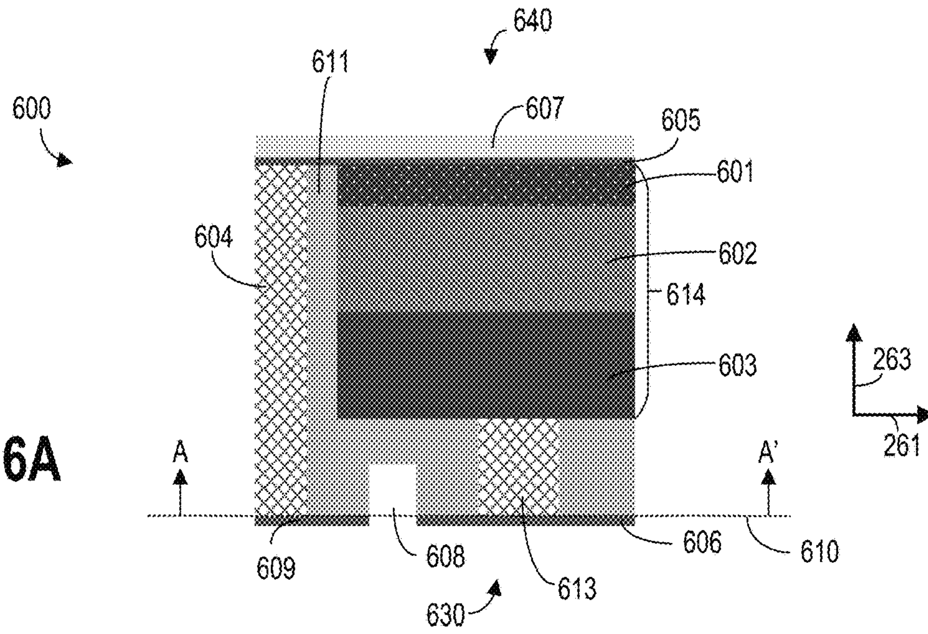


FIG. 6A

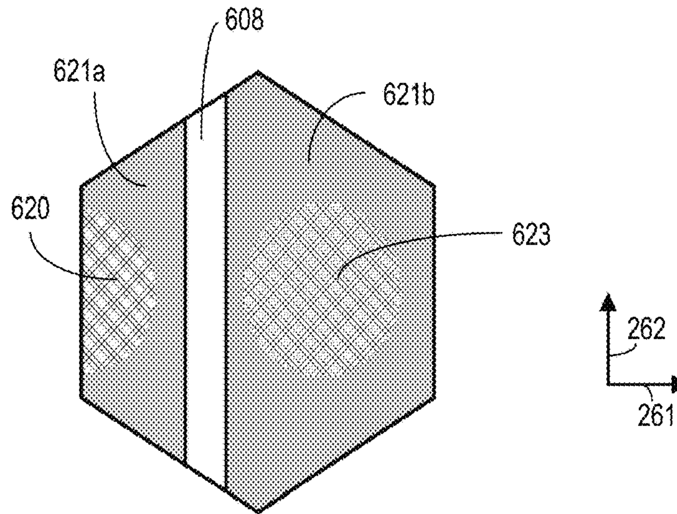


FIG. 6B

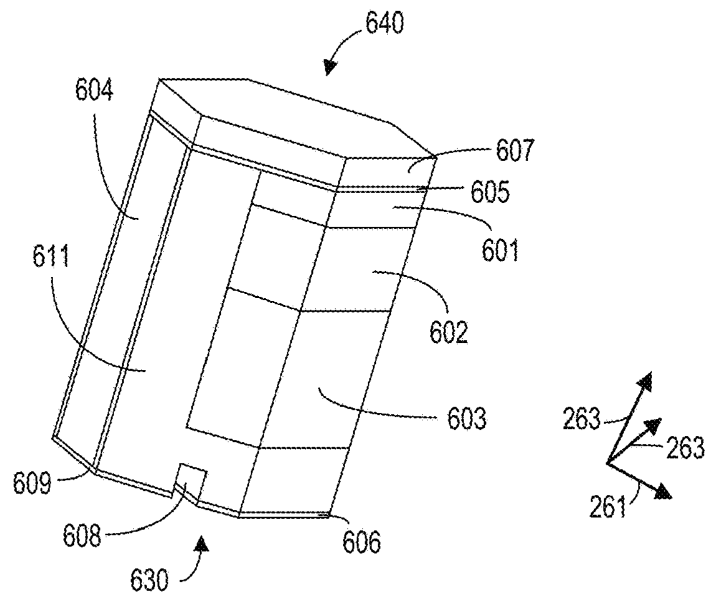


FIG. 6C

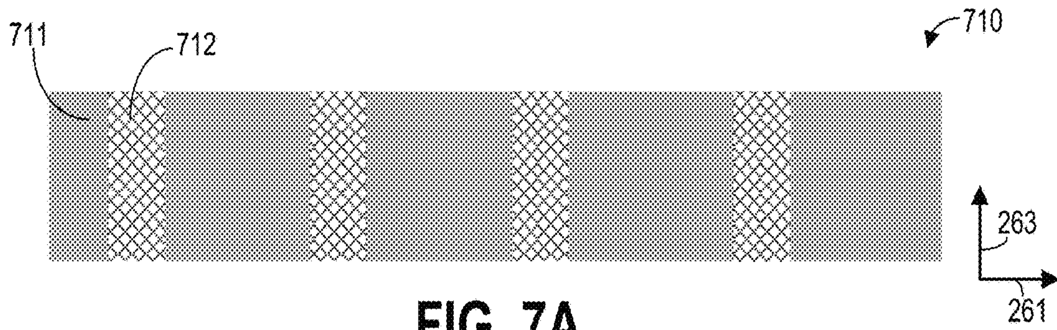


FIG. 7A

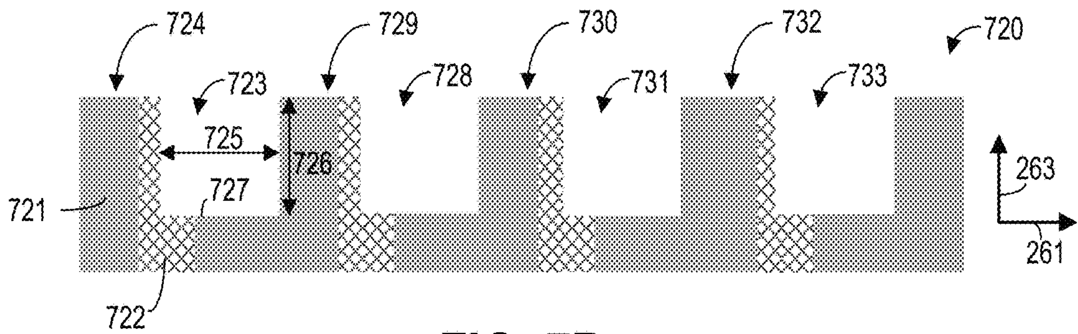


FIG. 7B

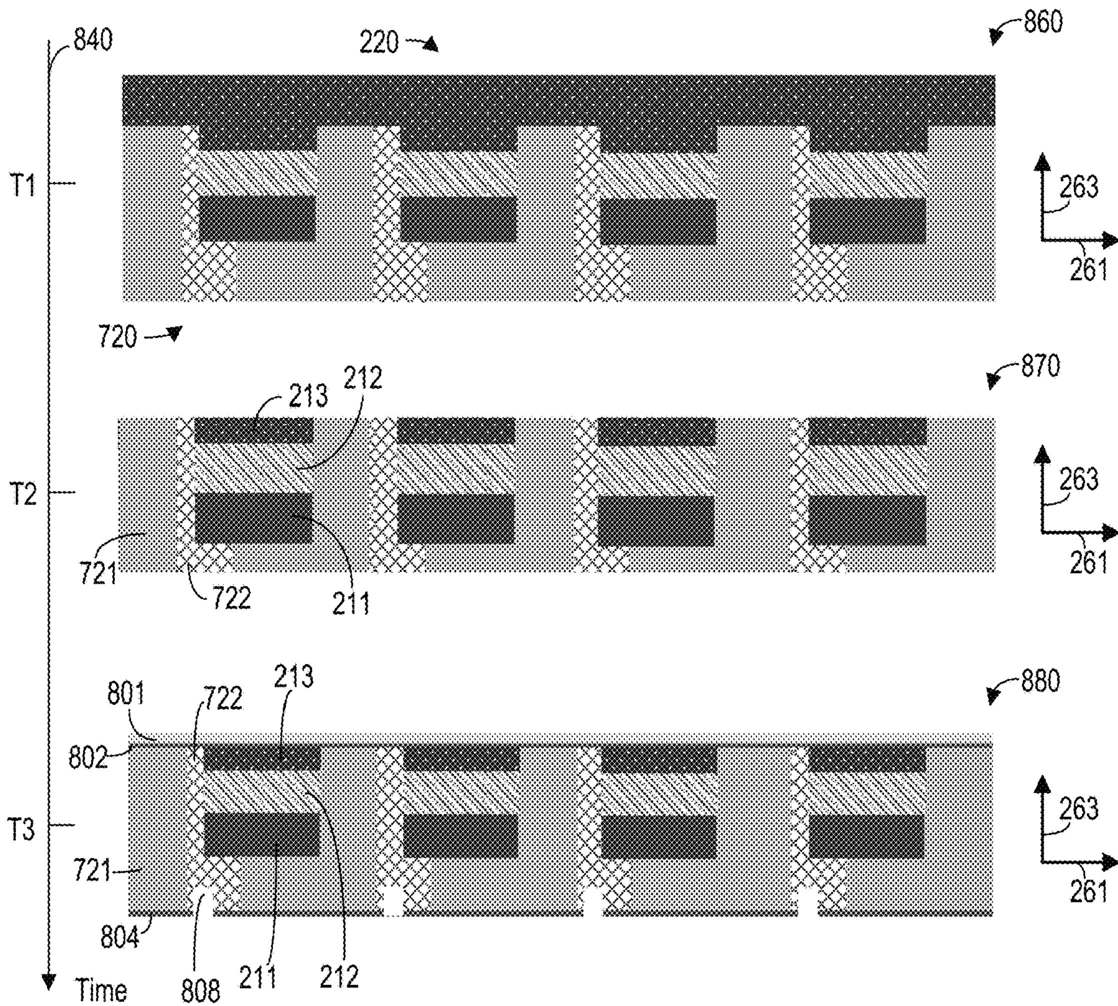


FIG. 8

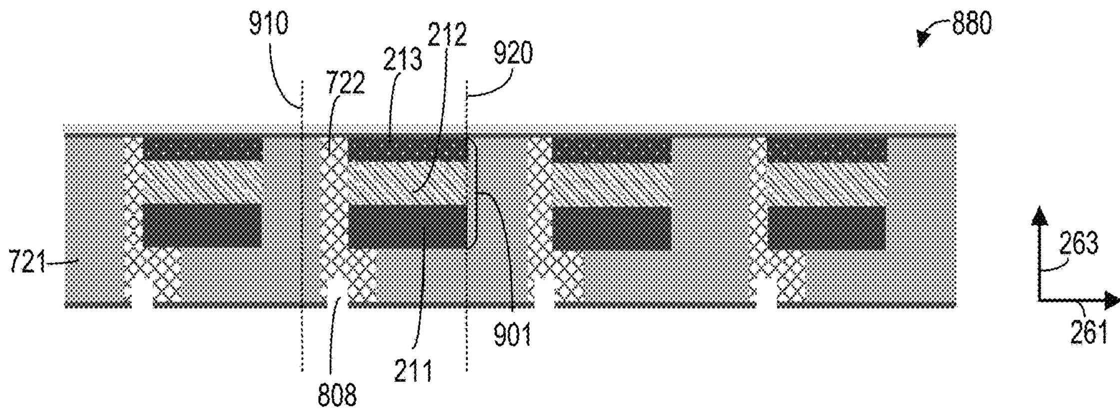


FIG. 9

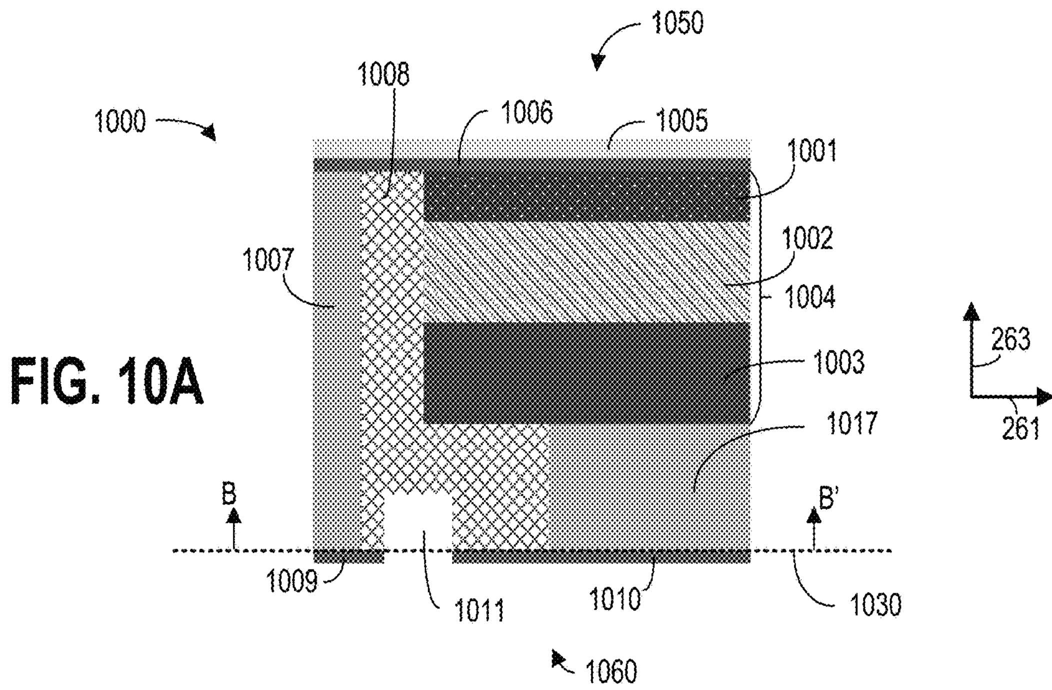


FIG. 10A

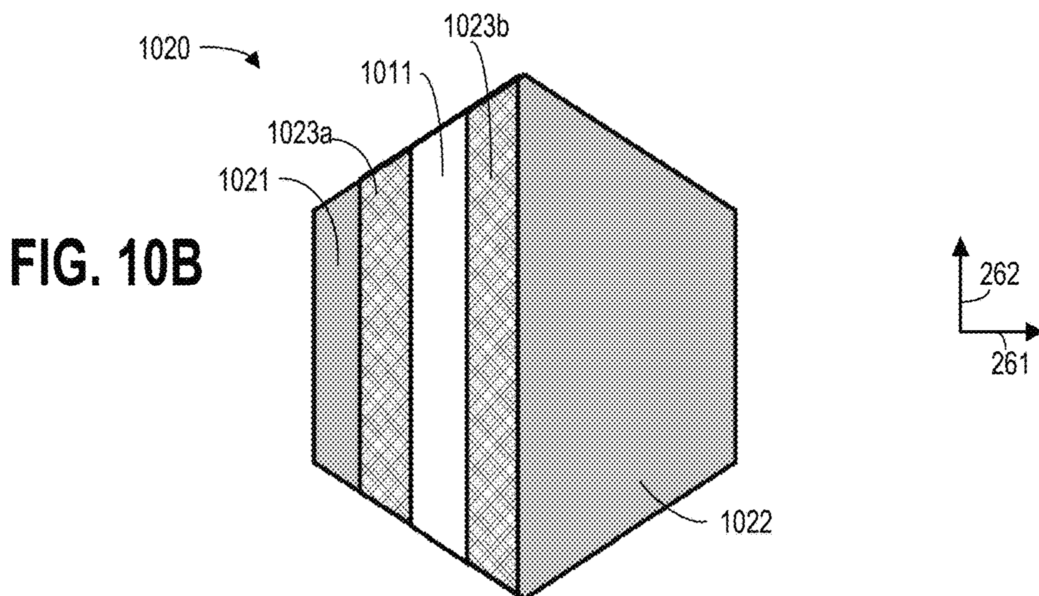


FIG. 10B

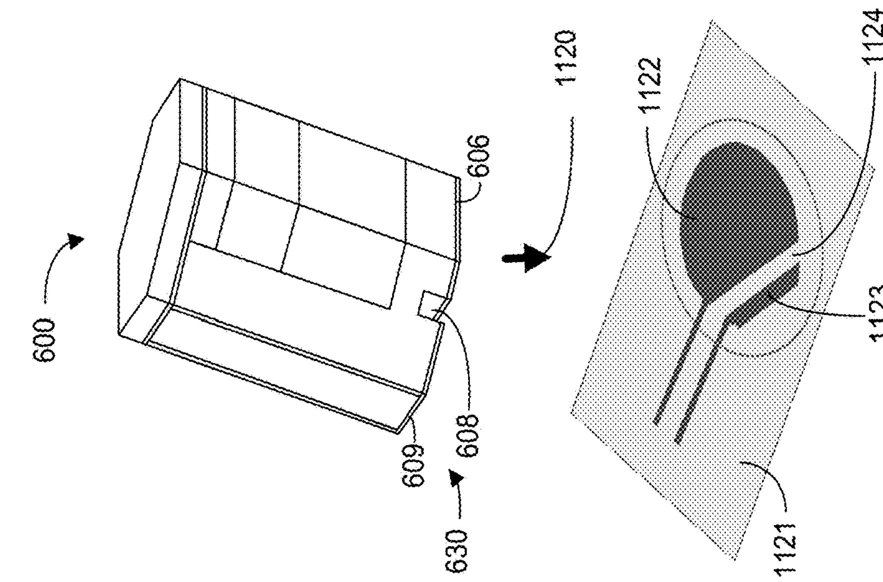


FIG. 11C

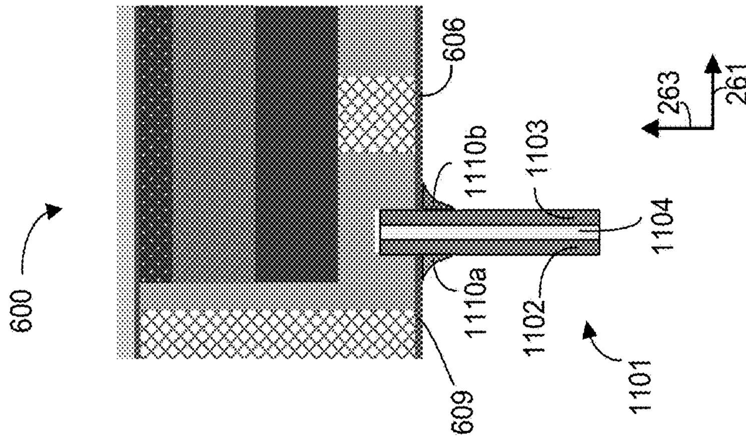


FIG. 11B

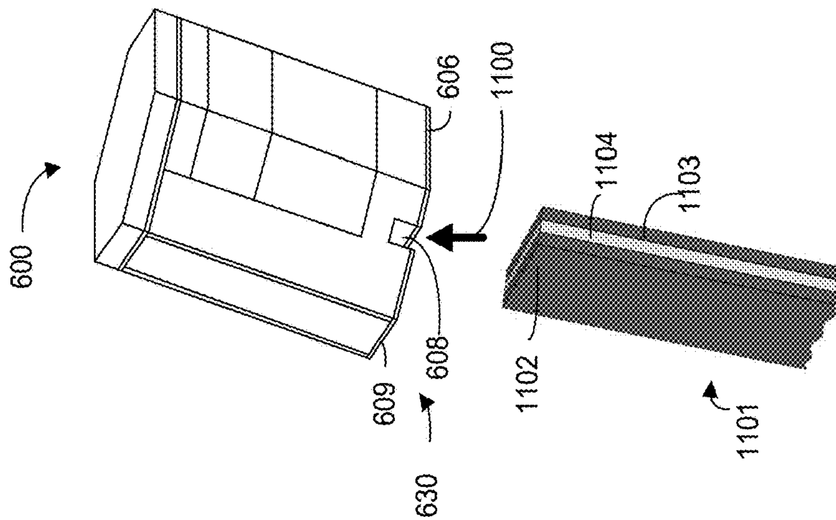


FIG. 11A

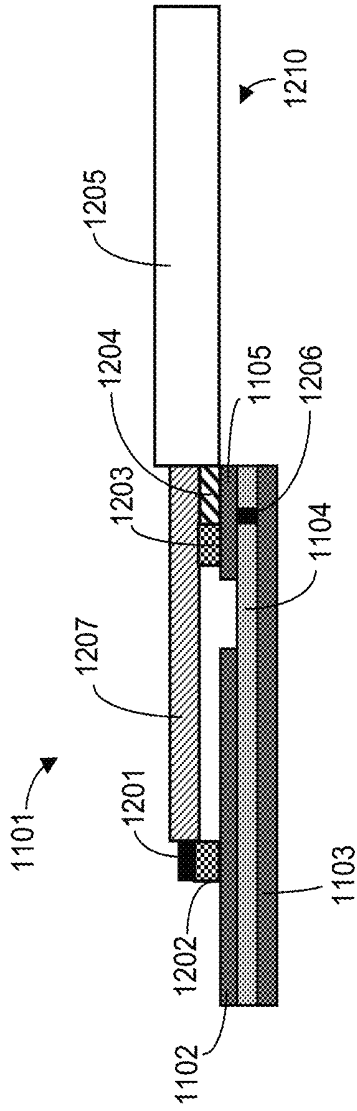


FIG. 12A

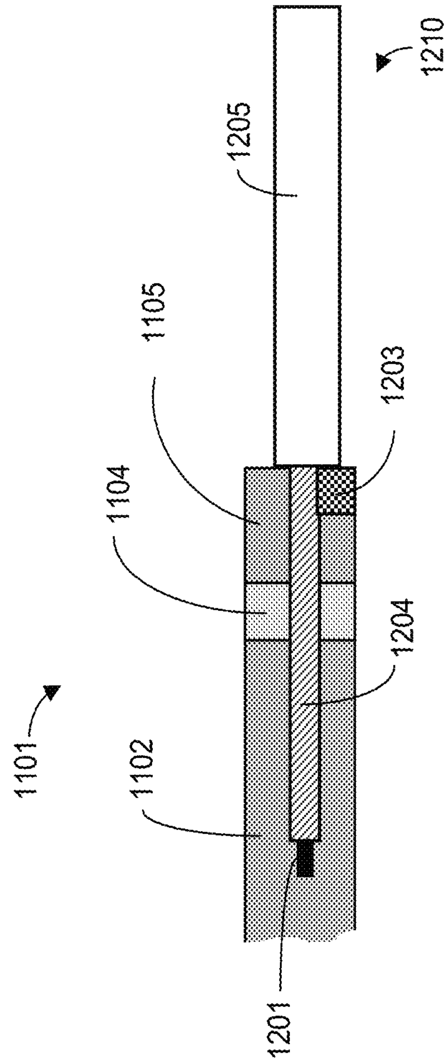


FIG. 12B

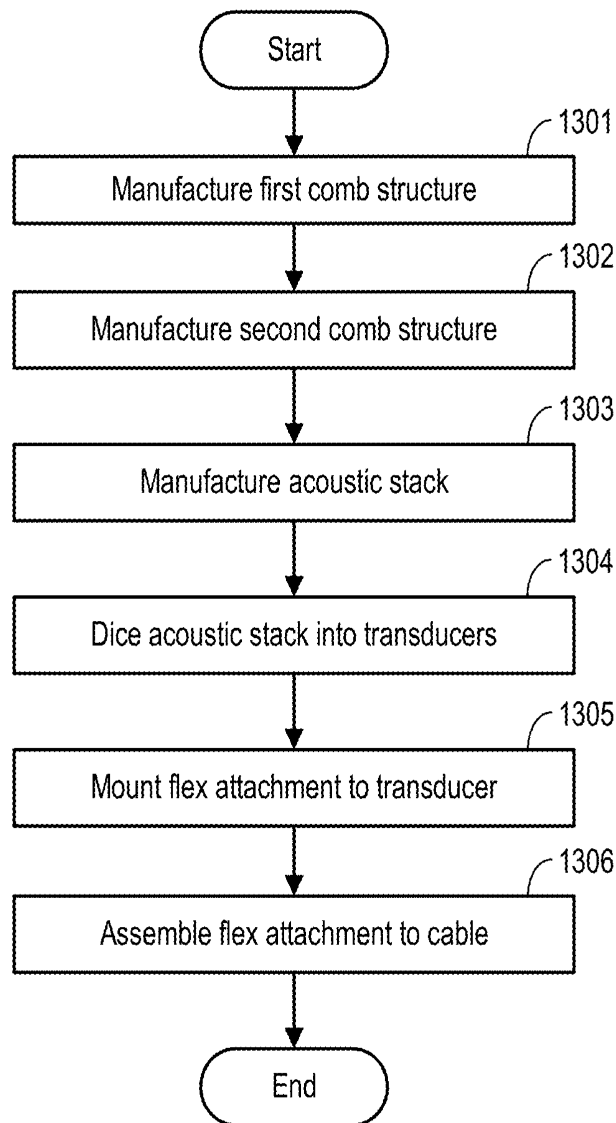


FIG. 13

ULTRASOUND TRANSDUCER AND METHOD FOR WAFER LEVEL BACK FACE ATTACHMENT

FIELD

Embodiments of the subject matter disclosed herein relate to an ultrasound transducer, and more particularly, to a single element ultrasound transducer with wafer level back face attachment.

BACKGROUND

Single element transducers can be mounted to a distal end of a probe for invasive imaging of blood vessels or cavities within the human body. By sending a voltage signal to the two electrodes of the transducer, a piezoelectric material within the transducer is excited and generates acoustic signals. The same piezoelectric material can also convert acoustic signals reflected from an object into voltage signals. The transducer may be assembled to a cable to form a forward looking probe, that is, a probe for imaging in the same direction as the longitudinal axis of the cable. The forward looking probe can be used in applications such as rectal imaging. Alternatively, the transducer may be assembled to a cable to form a side looking probe. By rotating the side looking probe along its longitudinal axis, a plane perpendicular to the longitudinal axis of the probe can imaged. The side looking probe can be used in applications such as intravascular imaging. Multiple single element transducers may also be assembled into a sparse array (such as a basket type array) for applications such as mapping a heart chamber. Since the ultrasound probes are designed for invasive imaging, miniaturized ultrasound transducers may be utilized.

Wiring the two electrodes of the transducer to the cable can be challenging due to the small size of the transducer. One approach is to attach one electrode of the transducer to a substrate having a printed circuit, and manually apply silver epoxy to connect the other electrode to the substrate. However, this process lacks reproducibility and robustness. Since silver epoxy has high viscosity, it is difficult to manually apply a controlled amount of epoxy. Silver epoxy also lacks robust adhesion to the substrate due to its high sensitivity to moisture and long curing time. Further, due to long touch time and cycle time, the process is not suitable for manufacturing disposable probes.

BRIEF DESCRIPTION

In one embodiment, an ultrasound transducer comprises a front face, a back face parallel to the front face, and a flex attachment. The back face includes a signal pad, a ground pad, and a groove separating the signal pad from the ground pad. The flex attachment has a first conductive layer and a second conductive layer separated by a non-conductive layer. The first conductive layer of the flex attachment is electrically coupled to the signal pad and the second conductive layer of the flex attachment is electrically coupled to the ground pad. In this way, the two electrodes (the ground pad and the signal pad) of the transducer are integrated into the transducer body with wafer level packaging, and the transducer may be reliably coupled to the probe via the flex attachment. Further, such configuration enables fast and automatic coupling of the transducer with the cable of the probe.

It should be understood that the brief description above is provided to introduce in simplified form a selection of concepts that are further described in the detailed description. It is not meant to identify key or essential features of the claimed subject matter, the scope of which is defined uniquely by the claims that follow the detailed description. Furthermore, the claimed subject matter is not limited to implementations that solve any disadvantages noted above or in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood from reading the following description of non-limiting embodiments, with reference to the attached drawings, wherein below:

FIG. **1** shows an example ultrasound system attached to a probe including a single element ultrasound transducer.

FIG. **2**A shows a layered substrate.

FIG. **2**B shows a first comb structure made with the layered substrate.

FIG. **2**C shows a non-conductive base package.

FIG. **2**D shows one embodiment of a second comb structure.

FIG. **3** shows a three dimensional rendering of the second comb structure of FIG. **2**D.

FIG. **4** illustrates a procedure for laminating the first and second comb structures of FIGS. **2**B and **2**D into an acoustic stack.

FIG. **5**A shows lateral dicing lines for cutting the acoustic stack of FIG. **4** into individual single element ultrasound transducers.

FIG. **5**B illustrates lateral and diagonal dicing lines for cutting the acoustic stack of FIG. **4** into individual single element ultrasound transducers.

FIG. **6**A shows a cross-sectional view of a first embodiment of a transducer.

FIG. **6**B shows a back surface of the transducer of FIG. **6**A.

FIG. **6**C shows a three dimensional rendering of the transducer of FIG. **6**A.

FIG. **7**A shows a substrate with conductive base package.

FIG. **7**B shows another embodiment of a second comb structure.

FIG. **8** shows the procedure of manufacturing an acoustic stack based on the second comb structure of FIG. **7**B.

FIG. **9** shows lateral dicing lines for manufacturing a second embodiment of a transducer.

FIG. **10**A shows a cross-sectional view of a second embodiment of the transducer.

FIG. **10**B shows a back surface of the transducer of FIG. **9**A.

FIG. **11**A illustrates the transducer of FIG. **6**A mounted to a flex attachment for a forward looking probe.

FIG. **11**B illustrates a cross-sectional view of the transducer of FIG. **6**A with the flex attachment mounted to a back face of the transducer.

FIG. **11**C illustrates the transducer of FIG. **6**A surface mounted to a flex pad for a side looking probe.

FIG. **12**A is a side view of the transducer of FIG. **6**A attached to the flex attachment.

FIG. **12**B is a top view of the transducer of FIG. **6**A attached to the flex attachment.

FIG. **13** shows a flow chart for manufacturing a transducer assembly.

DETAILED DESCRIPTION

The following description relates to various embodiments of a single element transducer. In particular, systems and

methods are provided for a single element ultrasound transducer with a wafer level back face attachment for constructing a forward looking or side looking ultrasound probe. FIG. **1** shows an example configuration of the forward looking probe within an ultrasound imaging system. The single element ultrasound transducer is manufactured through wafer level packaging, by dicing through an acoustic stack including interdigitated first comb structure and a second comb structure. Two embodiments of the transducer are presented. The two embodiments of the transducer are manufactured with the same first comb structure, but different second comb structures. In the first embodiment, the second comb structure includes a non-conductive base package and conductive vias. In the second embodiment, the second comb structure includes a conductive base package and non-conductive trench. FIGS. **2**A-**2**D illustrate an example procedure of manufacturing the first and the second comb structures with non-conductive base package. FIG. **3** shows a three dimensional rendering of the second comb structure. FIG. **4** shows the procedure of assembling an acoustic stack based on the first comb structure and the second comb structure with non-conductive base package. Individual transducers may be made by dicing the acoustic stack. FIGS. **5**A-**5**B show an example dicing pattern for a first embodiment of the transducer. The structure of the first embodiment of the transducer is show in FIGS. **6**A-**6**C. FIGS. **7**A-**7**B show another embodiment of the second comb structure with a conductive base package and non-conductive trenches. A procedure for assembling the first comb structure to the second comb structure with conductive base package is shown in FIG. **8**. The second embodiment of the transducer may be made by dicing the acoustic stack following lateral dicing lines shown in FIG. **9**. The second embodiment of the transducer, which is a negative to the first embodiment, is shown in FIGS. **10**A-**10**B. Both the first and the second embodiments of the transducer have a groove in the back face of the transducer. The groove can receive a distal end of a flex attachment as shown in FIGS. **11**A-**11**B for a forward looking probe. The first and the second embodiments of the transducer may also be surface mounted to a flat flex pad for a side looking probe as shown in FIG. **11**C. The proximal end of the flex attachment of FIGS. **11**A-**11**B may couple to a coaxial cable as shown in FIGS. **12**A-**12**B. FIG. **13** is a high level flow chart showing the method of manufacturing the transducer assembly with wafer level back face attachment.

Though a probe with a single element transducer is described by way of example, it should be understood that the present techniques may also be useful for constructing a probe with an array of forward looking single element transducers.

FIG. **1** is a schematic diagram of an ultrasound imaging system **100** in accordance with an embodiment of the invention. System **100** includes a display module **101**, a controller/processor **102**, a pulser/receiver **103**, and a probe **140**. The dash lines (**110**, **120**, and **130**) indicate communication of electrical signals between system components. A single element ultrasound transducer **105** is mounted at one distal end of cable **104**. The transducer **105** faces forward. In other words, the transducer generates and receives reflected acoustic signals in the same direction as the longitudinal axis **107** of the probe. The cable **104** may be a coaxial cable. In an example, the central axis of the coaxial cable may align with the longitudinal axis **107** of the probe. Probe **140** further includes a sheet **106** covering the cable **104** and the transducer **105**. The sheet may be flexible and transparent to acoustic signals.

Pulser/receiver **103** is controlled by the controller/processor **102** for generating a high voltage pulse to probe **140**. Reflected acoustic signals from an imaged object to the probe are converted into electrical signals and transmitted back to the pulser/receiver via **130**. The pulser/receiver may amplify the received electrical signals from the probe. The amplified received electrical signals are further transmitted to controller/processor **102** via dashed line **120**. An image or map of the imaged object is constructed based on the received electrical signals. The image or map may be sent to display **101** via dashed line **110** and/or stored in a memory.

In another embodiment, the probe may include an array of ultrasound transducers, and can image or sense a plane or a volume.

FIGS. **2**A-**2**D show a first comb structure and one embodiment of a second comb structure. Each comb structure includes fins and kerfs that are complimentary to each other. The two comb structures may be interdigitally laminated together to form an acoustic stack. In the figures, arrow **261** denotes a horizontal direction. Arrow **263** denotes a vertical direction, perpendicular to the horizontal direction. The lateral direction **262** is perpendicular to both the horizontal and vertical directions.

FIG. **2**A shows a cross-sectional view of a layered substrate **210** including a backing layer **211**, a matching layer **213**, and a piezoelectric layer **212** intermediate the backing layer and the matching layer. The backing layer, piezoelectric layer, and the matching layer are stacked vertically. The layers may be laminated together using epoxy glue or equivalent.

The piezoelectric layer may be made with a piezoelectric material, such as lead zirconate titanate or any other piezoelectric single crystal. The thickness of the piezoelectric layer may be half of the wavelength of the acoustic signal. The top surface and the bottom surface of the piezoelectric layer act as two electrodes. By applying a voltage across the two electrodes, the piezoelectric material is excited and generates acoustic signals in a direction parallel to the vertical direction. The piezoelectric material may also convert acoustic signals back into electrical signals. When the piezoelectric material is switched from the transmission to the receiving mode, a ringing effect may occur and affect the received signal. The backing layer can dampen the ringing effect. The backing layer may be made of conductive material such as graphite, porous graphite filled with resin, or aluminum. As another example, the thickness of the backing layer may depend on the required acoustic attenuation. In another embodiment, a dematching layer may be positioned between the piezoelectric layer and the backing layer. The dematching layer may be made of tungsten carbide. In yet another embodiment, the backing layer may be replaced with the dematching layer. The matching layer is for matching the acoustic impedance difference between the transducer and the medium that the transducer is immersed within during imaging. As an example, the matching layer may be configured to match the acoustic impedance difference between the transducer and water when the transducer is used for biological tissue imaging. The matching layer may be made of conductive material such as graphite, porous graphite filled with resin, stainless steel, or aluminum.

FIG. **2**B shows a cross-sectional view of the first comb structure **220**. The first comb structure may be made by dicing the layered substrate **210**. For example, the first comb structure **220** may be manufactured by dicing evenly spaced kerfs (**214**, **226**, and **228**) into the layered substrate **210**. The kerfs are of the same dimensions. The kerfs extend along the

lateral direction, and are evenly spaced along the horizontal direction. For example, kerf **214** extends vertically through the backing layer **211** and the piezoelectric layer **212**. Kerf **214** further extends into, but not through the matching layer **213**. As such, fins (**215**, **225**, **227**, and **229**) are formed. For example, fin **215** includes the backing layer **211**, the piezoelectric layer **212**, and part of the matching layer **213**. The adjacent fins **215** and **225** are separated by a kerf **214**.

FIG. **2**C shows a non-conductive base package **230**. The base package may be made by creating evenly spaced kerfs (**217**, **236**, **238**, and **251**) along the horizontal axis of a flat non-conductive substrate. The kerfs are of the same dimensions. For example, the substrate may be made with aluminum oxide (Al_2O_3) ceramic, polychlorinated biphenyl (PCB), or silicon. The non-conductive base package includes fins (**216**, **235**, **237**, and **239**) extending laterally. Two adjacent fins, such as fin **217** and fin **235**, are separated by a kerf, such as kerf **217**. As an example, the base package is complimentary to the first comb structure in a way that the height **218** of fin **216** in the base package is the same as the height **219** of fin **215** in the first comb structure, and the width **232** of fin **215** in the first comb structure is less than the width **233** of kerf **217** in the base package. In other words, the respective height of the fins are the same in both the first comb structure and the base package and the respective width of the fins in the first comb structure are less than the respective width of the kerfs in the base package.

FIG. **2**D shows a cross-section of a second comb structure **240**, which is formed from the base package **230**. The second comb structure has fins (**246**, **271**, **273**, and **275**) and kerfs (**247**, **272**, **274**, and **276**) complimentary to the fins and kerfs of the first comb structure **220**. The second comb structure has vertically conductive vias. The second comb structure may be made by drilling a plurality of first vias (**241**, **278**, **280**, and **282**) and a plurality of second vias (**242**, **279**, **281**, and **283**) vertically through the non-conductive base package **230**, and filling the vias with conductive material such as tungsten or copper. In one embodiment, the non-conductive base package is made of Al_2O_3, while the conductive vias are filled with tungsten. In another embodiment, the non-conductive base package is made of PCB or silicon, and the conductive vias are filled with copper. For example, first via **241** is drilled through fin **216** of the non-conductive base package, from the top surface **231** of fin **216** to the bottom surface **270** of base package **230**. The second via **242** is drilled through the bottom surface **234** of kerf **217** to the bottom surface **270** of base package **230**. As such, the second comb structure includes alternating first and second vias along the horizontal axis. The entirety of the depth of each of the vias is filled with the conductive material. In other words, in the second comb structure **240**, the filling for the first via **241** has a top surface within the same plane of the top surface **248** of fin **246**; and the filling for second via **242** has a top surface within the same plane of the bottom surface **249** of kerf **247**. In this way, the second comb structure **240** and the first comb structure **220** can be laminated together into an acoustic stack with interdigitated kerfs and fins.

Herein, a top surface of a layer refers to a flat surface extending horizontally and laterally, and is higher than a bottom surface, wherein the increased height in the vertical direction is indicated by arrow **263**. The side of a layer refers to a side surface of the layer parallel to the vertical axis.

FIG. **3** shows a three dimensional rendering of the second comb structure **240**. As shown in FIG. **3**, the vias (e.g., vias **241** and **242**) are cylindrical in shape, with a round top surface. However, other via shapes are possible, such as rectangular, oval, etc. The first conductive via **241** is embedded within the fin **246**. The top surface of the second conductive via **242** is at the bottom of kerf **247**, surrounded by the non-conductive base package **245**. Both fin **246** and kerf **247** extend laterally along the entirety of the second comb structure.

FIG. **4** illustrates a procedure of constructing an acoustic stack from the first and second comb structures. Arrow **261** denotes a horizontal direction. Arrow **263** denotes a vertical direction, perpendicular to the horizontal direction. The lateral direction **262** is perpendicular to both the horizontal and vertical directions. Axis **450** indicates time. The time increases as indicated by the arrow.

At T**1**, the first comb structure **220** is laminated with the second comb structure **240** to form a laminated stack **410**. Specifically, the fins of the first comb structure are inserted into the kerfs of the second comb structure, and fins of the second comb structure are inserted into the kerfs of the first comb structure. The two comb structures may be bonded by applying glue in between. As an example, the glue may be non-conducting glue such as epoxy. As another example, the glue may include an anisotropic conductive paste in the vertical direction separating the base package from the matching layer, piezoelectric layer, and the backing layer.

At T**2**, the laminated stack **410** is ground into ground stack **420**. Specifically, the top surface of the laminated stack **410** is ground so that part of the matching layer is removed. As an example, in the ground stack **420**, the thickness of the matching layer **213** may be one fourth of the wavelength of the acoustic signal. The matching layer **213** is of the same width in the horizontal direction and same depth in the lateral direction as the piezoelectric layer **212** and the backing layer **211**. As such, the top surface of the first via **241** is part of the top surface of ground stack **420**. The first via **241** is separated from the piezoelectric layer **212** by base package **245**. In another embodiment, the bottom surface of the laminated stack **410** may also be ground to remove part of the base package, in order to adjust the thickness of the transducer to a desired thickness.

At T**3**, the top surface and the bottom surface of the ground stack **420** are plated with a first conductive coating **431** and a second conductive coating **432**, respectively. The coating may be copper, gold, or any type of metal deposition, Further, a second matching layer **433** is deposited on top of the first conductive coating **431**. As an example, the second matching layer may be chosen in order to optimize acoustic energy transmission. The second matching layer may have acoustic impedance between 1.5 and 4MRayl. The second matching layer may be electrically conductive or non-conductive.

At T**4**, an acoustic stack **440** is made by dicing grooves at the bottom of the coated stack **430** with a dicing saw, for example. As shown, groove **441** extends laterally and cuts through the second conductive coating **432**, and into but not through the base package **245**. Each groove separates a respective first via and second via, such as groove **441** separating first via **241** and second via **242**. Each groove is separated from the backing layer **211** by the non-conductive base package **245**.

FIGS. **5**A and **5**B show example patterns for dicing the acoustic stack **440** into individual hexagonal single element transducers. The acoustic stack **440** may be cut along lateral dicing and diagonal dicing lines. FIG. **5**A shows an example first lateral dicing line **501** and an example second lateral dicing line **502** in the cross-sectional view of the acoustic stack **440**. The first dicing line **501** extends vertically along

the first via **241**, separating the first via into two parts. The distance **503** between the first dicing line **501** and the second dicing line **502** along the horizontal direction is large enough so that part or all of the second via **242** is within the transducer between dicing line **501** and **502**. As another example, the second via **242** and the second dicing line **502** are separated by the base package **245**. As yet another example, the second dicing line **502** may be along the side surface **505** of a layered stack **429**. The layered stack includes the matching layer **213**, the piezoelectric layer **212**, and the backing layer **211**. FIG. **5**B shows example diagonal dicing lines, such as line **504**, as well as the lateral dicing lines **501** and **502** in a three dimensional rendering of acoustic stack **440**.

In another embodiment, transducers of other shapes may be diced out of the acoustic stack. For example, the acoustic stack may be diced along lateral and horizontal, instead of diagonal, dicing lines into rectangular transducers.

FIGS. **6**A-**6**C show different views of a hexagonal single element ultrasound transducer **600** diced from the acoustic stack **440** as shown in FIGS. **5**A-**5**B. The transducer includes a groove at the back face of the transducer. The groove separates a ground pad and a signal pad of the transducer. A flex attachment may be inserted to the groove for coupling the transducer to a coaxial cable.

FIG. **6**A is a cross-sectional view of transducer **600**. The transducer includes a layered stack **614** comprising a matching layer **601**, a piezoelectric layer **602**, and a backing layer **603**. The layered stack **614** is separated from a first conductive via **604** by a non-conductive base package **611**. The bottom surface of the backing layer **603** is in contact with a second conductive via **613**. The top surface of the first conductive via **604**, the top surface of the non-conductive base package **611**, and the top surface of the matching layer **601** define a front surface of the transducer. A first conductive coating **605** is plated onto the front surface of the transducer. The first conductive coating **605** is between the front surface of the transducer and a second matching layer **607**. The second matching layer **607** forms the front face **640** of the transducer. The groove **608** is embedded within the non-conductive base package **611**. The bottom surface of the first conductive via **604**, the bottom surface of the non-conductive base package **611**, and the bottom surface of the second conductive via **613** define a back surface of the transducer. A second conductive coating (such as **432** in FIG. **4**) is applied over the back surface. The second conductive coating forms a signal pad **609** and a ground pad **606** separated by groove **608**. The bottom surfaces of the ground pad **606** and the signal pad **609** define a back face **630** of the transducer. The back face of the transducer is parallel with the front face of the transducer. The signal pad **609** is in direct contact with the bottom surface of the first via **604**. The ground pad **606** is in direct contact with the bottom surface of the second via **613**. The first conductive via **604** extends vertically from the signal pad **609** to the first conductive coating **605**. The second conductive via **613** extends vertically from the ground pad **606** to the bottom surface of the backing layer **603**. As such, the transducer is one solid piece with the signal pad and the ground pad integrated to its body.

The ground pad **606** is electrically coupled with one electrode of the piezoelectric layer **602** via the second conductive via **613** and the backing layer **603**. The signal pad **609** is electrically coupled with the other electrode of the piezoelectric layer **602** via the first conductive via **604**, the first conductive coating **605**, and the matching layer **601**. To generate an acoustic signal, a voltage potential may be applied to the transducer by electrically coupling a positive tab of a power source to the signal pad, and a negative (or ground) tab of the power source to the ground pad of the transducer. Alternatively, a voltage potential may be applied to the transducer by electrically coupling a positive tab of the power source to the ground pad of the transducer, and the negative tab (or ground) tab of the power source to the signal pad of the transducer. In other words, the signal and ground pad of the transducer are interchangeable.

FIG. **6**B shows the back surface of the transducer, viewed along **610** in a direction A-A'. The back surface includes the bottom surface **620** of the first conductive via **604**, the bottom surface (**621***a* and **621***b*) of the non-conductive base package **611**, the bottom surface **623** of the second conductive via **613**, and groove **608**. The back surface of the transducer is in hexagon shape. The groove **608** separates the bottom surface of the non-conductive base package in two parts **621***a* and **621***b*, each part including a bottom surface of one conductive via.

FIG. **6**C is a three dimensional rendering of the hexagonal transducer **600**. The non-conductive base package **611** partially surrounds the first matching layer **601**, piezoelectric layer **602**, and the backing layer **603**. The first conductive via **604** extends vertically. The front surface of the transducer is formed by the top surfaces of first conductive via **604**, the base package **611**, and the matching layer **601**. The first conductive coating **605** is between the front surface of the transducer and the second matching layer **607**. The groove **608** separates the signal pad **609** and the ground pad **606** of the back face of the transducer.

FIGS. **7**A-**7**B show a second embodiment for a second comb structure of the ultrasound transducer. The second comb structure includes a conductive base package with non-conductive trenches.

FIG. **7**A is a cross-sectional view of a substrate **710** with non-conductive trenches evenly spaced along the horizontal direction. The substrate **710** may be manufactured by dicing trenches through a conductive base package **711**, filling the trenches entirely with non-conductive material, and grinding the top and bottom surface of the substrate. As such, the top surface of the trench **712** is within the same plane as the top surface of the base package **711**. The bottom surface of trench **712** is within the same plane as the bottom surface of the base package **711**. In one embodiment, the non-conductive trench may be non-conductive resin such as epoxy glue, and the base package may be graphite.

FIG. **7**B shows a second comb structure **720** with conductive base package **721**. The second comb structure **720** may be made by dicing substrate **710** to form evenly spaced kerfs (**723**, **728**, **731**, and **733**). For example, in order to form the kerf **723**, part of the non-conductive trench **712** is removed as well as part of the conductive base package **711** along the horizontal direction. The bottom surface **727** of the kerf **723** abuts both the non-conductive trench **722** and the conductive base package **721**. The second comb structure includes fins (**724**, **729**, **730**, and **732**) and kerfs complimentary to the fins and kerfs in first comb structure **220** shown in FIG. **2**B. Specifically, the heights of the fins in the first comb structure are the same as the heights (e.g., height **726**) of the fin in the second comb structure **720**. The width (e.g., width **725**) of the kerf in the second comb structure **720** are not less than the width of the fins in the first comb structure.

FIG. **8** illustrates a procedure for manufacturing an acoustic stack **880** with the first comb structure **220** and the second comb structure **720**. Arrow **261** denotes a horizontal direction. Arrow **263** denotes a vertical direction, perpendicular

to the horizontal direction. The lateral direction **262** is perpendicular to both the horizontal and vertical directions. Axis **840** indicates time. The time increases as indicated by the arrow.

At T**1**, the first comb structure **220** is laminated with the second comb structure **720** to form a laminated stack **860**. Specifically, the fins of the first comb structure are inserted into the kerfs of the second negative comb structure, and the fins of the second negative comb structure are inserted into the kerfs of the first comb structure. The two comb structures may be bonded by a glue. As an example, the glue may be non-conducting glue such as epoxy. As another example, the glue may include an anisotropic conductive paste in the vertical direction separating the base package from the matching layer, piezoelectric layer, and the backing layer.

At T**2**, the laminated stack **860** is ground into ground stack **870**. Specifically, the top surface of the laminated stack **860** is ground so that the matching layer **213** is of the same width in the horizontal direction and the same depth in the lateral direction as the piezoelectric layer **212** and the backing layer **211**. As an example, thickness of the matching layer **213** may be one fourth of the wavelength of the acoustic signal. As such, the top surface of the non-conductive trench **722** is part of the top surface of ground stack **870**. The non-conductive trench **722** is in contact with the side surface of the layered stack including the matching layer **213**, the piezoelectric layer **212**, and the backing layer **211**. The non-conductive trench **722** separates the base package **721** from the piezoelectric layer **212**. In another embodiment, the bottom surface of the laminated stack may also be ground to remove part of the base package, in order to adjust the thickness of the transducer to a desired thickness.

At T**3**, acoustic stack **880** is made. In an example, a first conductive coating **802** may be first plated over the top surface of the ground stack **870**, and then a second matching layer **801** is deposited on top of the first conductive coating. The second matching layer may be electrically conductive or non-conductive. A second conductive coating **804** may be plated over the bottom surface of the ground stack **870**. Then, grooves are created by dicing through the second conductive coating **804** and into the non-conductive trench **722**. An example groove **808** is shown.

The acoustic stack **880** may be diced into individual transducers. FIG. **9** shows example lateral dicing lines for dicing the acoustic stack **880** into individual transducers. As an example, the acoustic stack **880** is diced in the horizontal direction by a first dicing line and a second dicing line. For example, a first dicing line **910** is between the non-conductive trench **722** and the layered stack **901**. The layered stack **901** includes the matching layer **213**, piezoelectric layer **212**, and the backing layer **211**. A second dicing line **920** may be along the side surface of the layered stack **901**. The first and second dicing lines are on opposite sides of the groove **808**.

In one embodiment, the acoustic stack may be diced into hexagonal transducers with lateral dicing lines **910** and **920**, and diagonal dicing lines (such as **504** of FIG. **5**B). In another embodiment, the acoustic stack may be diced into rectangular transducers with lateral dicing lines **910** and **920**, and horizontal dicing lines that are perpendicular to the lateral dicing lines.

FIGS. **10**A-**10**B show one embodiment of a hexagonal transducer **1000** diced out of acoustic stack **880** of FIG. **9**. The transducer **1000** is a negative of transducer **600**, e.g., in transducer **600**, the base package is non-conductive and the vias are conductive; in transducer **1000**, the base packages are conductive and the trench is non-conductive. FIG. **10**A is a cross-sectional view of the transducer. The first matching layer **1001**, piezoelectric layer **1002**, and the backing layer **1003** form the layered stack **1004**. A non-conductive trench **1008** separates a first conductive base package **1007** and a second conductive base package **1017**. The first and second conductive base packages are constructed from base package **721**. The bottom surface of the backing layer **1003** is in contact with the non-conductive trench **1008** and the second conductive base package **1017**. The top surface of the first conductive base package **1007**, the top surface of the non-conductive trench **1008**, and the top surface of the first matching layer **1001** define a front surface of the transducer. A first conductive coating **1006** is deposited on top of the front surface, intermediate the front surface and a second matching layer **1005**. The top surface of the second matching layer defines a front face **1050** of the transducer. The bottom surface of the first conductive base package **1007**, the bottom surface of the non-conductive trench **1008**, and the bottom surface of the second conductive base package **1017** define a back surface **1020** of the transducer. A second conductive coating is applied to the back surface. A groove **1011** cuts through the second conductive coating and separates the second conductive coating into a signal pad **1009** and a ground pad **1010**. The bottom surfaces of the signal pad and the ground pad define a back face **1060** of the transducer. The back face is parallel to the front face of the transducer. The groove **1011** also cuts into, but not through, the non-conductive trench **1008**. Details of the back surface **1020** is shown in FIG. **10**B. The signal pad **1009** is in contact with the bottom surface of the first conductive base package **1007**. The ground pad **1010** is in contact with the bottom surface of the second conductive base package **1017**. The first base package **1007** extends vertically from the signal pad **1009** to the first conductive coating **1006**. The second base package **1017** extends vertically from the ground pad **1010** to the bottom surface of the backing layer **1003**.

The ground pad **1010** is electrically coupled with the bottom surface of the piezoelectric layer **1002** via the second conductive base package **1017** and the backing layer **1003**. The signal pad **1009** is electrically coupled with the top surface of the piezoelectric layer **1002** via the first conductive base package **1007**, the first conductive coating **1006**, and the first matching layer **1001**. As such, when a voltage is applied across the signal pad and the ground pad, the piezoelectric layer **1002** is excited and generates acoustic signals in a direction from the back face **1060** to the front face **1050** of the transducer. A flex attachment may be inserted into the groove **1011** to couple the two electrodes (the signal and ground pads) of the transducer to a coaxial cable.

FIG. **10**B shows the back surface **1020** of transducer **1000** viewing from line **1030** in direction B-B'. Groove **1011** separates the bottom surface of the non-conductive trench **1008** into two parts (**1023***a* and **1023***b*). The groove **1011** and the bottom surface (**1023***a* and **1023***b*) of the non-conductive trench, insulating the bottom surface **1021** of the first conductive base package **1007** from the bottom surface **1022** of the second conductive base package **1017**. The signal pad **1009** covers the bottom surface **1021** of the first conductive base package and the first bottom surface **1023***a* of the non-conductive trench. The ground pad **1010** covers the bottom surface **1022** of the second conductive base package and the second bottom surface **1023***b* of the non-conductive trench.

FIG. **11**A illustrates a flex attachment **1101** having a distal end configured to be inserted into the groove of the single element ultrasound transducer. As a non-limiting example, the hexagonal transducer **600** is shown here. The flex

attachment is inserted into the groove as shown by arrow **1100**. The flex attachment includes a non-conductive middle layer **1104** intermediate a first conductive layer **1102** and a second conductive layer **1103**. The non-conductive middle layer **1104** may be kapton and the first and second conductive layers may be copper or gold coated copper, at least in one example. By inserting the flex attachment into the groove, the signal pad **609** is in contact with the first conductive layer **1102** and the ground pad **606** is in contact with the second conductive layer **1103**. Conductive glue or soldering may be applied to further bond the signal or ground pad with the respective conductive layer. The flex attachment may be a flex PCB. Alternatively, the flex attachment may be of another substrate utilizing surface mounted attachment, such as ASICs and 3DMID. The other distal end of the flex attachment **1101** may be electrically coupled to a processor, such as an imaging system. The other distal end of the flex attachment may be coupled to the processor through a cable, such as a coaxial cable as shown in FIG. **12**.

FIG. **11**B illustrates a cross-sectional view of the transducer with flex attachment **1101** mounted to its back face. The signal pad **609** of the transducer is in contact with the first conductive layer **1102** of the flex attachment. The ground pad **606** of the transducer is in contact with the second conductive layer **1103** of the flex attachment. Conductive glue or soldering **1110***a* and **1110***b* are applied to ensure the signal pad **609** is electrically bonded with the first conductive layer **1102** and the ground pad **606** is electrically bonded with the second conductive layer **1103**, respectively.

FIG. **11**C illustrates surface mounting the single element transducer to a flat flex pad **1121** for a side looking probe. The flex pad includes circuit printed on one surface of the flex pad. As an example, the flex pad may be polyimide. The circuit may be printed on the flex pad with copper. The circuit may include a signal pad **1123** and a ground pad **1122**. The signal pad and the ground pad are separated by non-conductive groove **1124**. As indicated by arrow **1120**, back face **630** of the transducer may be laminated to the flex pad by aligning the signal pad **609** of the transducer with the signal pad **1123** of the flex pad, aligning the ground pad **606** of the transducer with the ground pad **1122** of the flex pad, and aligning groove **608** of the transducer with the non-conductive groove **1124** of the flex pad.

FIGS. **12**A and **12**B show the proximal end of the flex attachment **1101** assembled with a coaxial cable **1210**. FIG. **12**A is a side view of the assembly, and FIG. **12**B is a top view of the same assembly. The coaxial cable **1210** includes a jacket **1205**, a coaxial ground **1204**, and a coaxial signal **1201**. The coaxial ground may be insulated from the coaxial signal with a dielectric insulator **1207**. The coaxial signal **1201** is bonded to the first conductive layer **1102** of the flex attachment with soldering **1202**. Conductive strip **1105** is attached to the non-conductive middle layer **1104**, and is on the same side of the first conductive layer **1102** relative to the non-conductive middle layer **1104**. The conductive strip may be of the same material as the conductive layers. The coaxial ground **1204** is bonded with the conductive strip **1105** with soldering **1203**. The conductive strip **1105** is connected with the second conductive layer **1103** by a conductive via **1206** through the non-conductive middle layer **1104**. In this way, the coaxial signal is electrically coupled with the signal pad of the transducer via the first conductive layer of the flex attachment; the coaxial ground is electrically coupled with the ground pad of the transducer via the conductive strip **1105**, the conductive via **1206**, and the second conductive layer **1103** of the flex attachment. Electrical signals may be sent and received to and from the transducer via the coaxial cable.

FIG. **13** shows an example method **1300** for manufacturing an ultrasound transducer assembly with its back face coupled to a coaxial cable.

At **1301**, a first comb structure is manufactured. The first comb structure includes fins and kerfs. The first comb structure may be made by dicing kerfs into a layered substrate including a piezoelectric layer intermediate a matching layer and a backing layer. An example of the first comb structure is shown in FIG. **2**B

At **1302**, a second comb structure is manufactured. The second comb structure includes fins and kerfs complimentary to the first comb structure. The second comb structure may be made out of a non-conductive substrate or a conductive substrate. In one embodiment, a non-conductive base package may be made by dicing kerfs into a non-conductive substrate. Then, through vias are drilled into the base package, and filled with conductive material. An example of the second comb structure with non-conductive base package is shown in FIG. **2**D. In another embodiment, through trenches may first be cut into a conductive substrate, and filled with non-conductive material. Then, kerfs are cut into the substrate to construct the second comb structure with conductive base package, as shown in FIG. **7**B.

At **1303**, an acoustic stack is constructed from the first and second comb structures. The first and second comb structures are first laminated together, then ground and plated with conductive coating on the top and bottom surfaces. Further, grooves are cut into the bottom surface of the plated substrate with a dicing saw, for example. The procedures of manufacturing the acoustic stack is shown in FIG. **4**.

At **1304**, the acoustic stack is diced into individual ultrasound transducers. An example pattern for dicing the acoustic stack with non-conductive base package is shown in FIGS. **5**A-**5**B. Another example of dicing lines for dicing the acoustic stack with conductive base package is shown in FIG. **9**.

At **1305**, the distal end of a flex attachment is mounted to the back face of the transducer. As an example, FIGS. **11**A-**11**B show a layered flex attachment inserted into the groove of the back face of a hexagonal transducer for constructing a forward looking probe. As another example, a side looking probe may be constructed by surface mounting the back face of a hexagonal transducer onto a flat flex pad with printed circuit printed on top, as shown in FIG. **11**C.

At **1306**, the other end of the flex attachment is coupled to a cable. For example, FIGS. **12**A-**12**B show an example assembly of the flex PCB with a coaxial cable.

A technical effect of a single element ultrasound transducer with two electrodes integrated into the back end of the transducer is easy attachment to a cable. Another technical effect of the transducers disclosed herein is enabling simple assembly of the transducer with a coaxial cable via a flex attachment including a non-conducive layer intermediate two conductive coating. Another technical effect of the transducer with a wafer level back face attachment is that the electrodes of the transducer may be directly coupled to a coaxial cable with minimal wiring. Another technical effect of the disclosure is that the transducer may be automatically assembled with a coaxial cable, avoiding manually depositing epoxy. Another technical effect of the disclosure is that the transducer may function reliably and robustly.

In one embodiment, an ultrasound transducer comprises a front face, a back face parallel to the front face, the back face having a signal pad, a ground pad, and a groove separating

the signal pad from the ground pad, and a piezoelectric layer having a top surface electrically coupled to the signal pad and a bottom surface electrically coupled to the ground pad. In a first example of the embodiment, the ultrasound transducer further comprises a flex attachment having a first conductive layer and a second conductive layer separated by a non-conductive layer, the first conductive layer in contact with the signal pad, the second conductive layer in contact with the ground pad, the piezoelectric layer intermediate a matching layer and a backing layer. A second example of the embodiment optionally includes the first example and further includes, a first conductive via extending vertically from the signal pad to a conductive coating over a top surface of the matching layer, and the signal pad is electrically coupled to the top surface of the piezoelectric layer through the first conductive via, the conductive coating, and the matching layer. A third example of the embodiment optionally includes one or more of the first and second examples, and further includes a second conductive via, and the ground pad is electrically coupled to the bottom surface of the piezoelectric layer through the second conductive via and the backing layer. A fourth example of the embodiment optionally includes one or more of the first through third examples, and further includes, further comprising a non-conductive base package separating the first conductive via from the second conductive via. A fifth example of the embodiment optionally includes one or more of the first through fourth examples, and further includes, the second conductive via is in cylindrical shape and is surrounded by the non-conductive base package. A sixth example of the embodiment optionally includes one or more of the first through fifth examples, and further includes, a first conductive base package extending vertically from the signal pad to a conductive coating over the matching layer, and the signal pad is electrically coupled to the top surface of the piezoelectric layer through the first conductive base package, the conductive coating, and the matching layer. A seventh example of the embodiment optionally includes one or more of the first through sixth examples, and further includes, a second conductive base package extending vertically from the ground pad to the back surface of the backing layer, and the ground pad is electrically coupled to the bottom surface of the piezoelectric layer through the second conductive base package and the backing layer. An eighth example of the embodiment optionally includes one or more of the first through seventh examples, and further includes, a non-conductive trench between the first conductive base package and the second conductive base package. An ninth example of the embodiment optionally includes one or more of the first through eighth examples, and further includes, a flat flex pad with circuit printed on one surface, wherein the back face of the transducer is laminated on top of the flex pad.

In another embodiment, an ultrasound transducer assembly, comprises a piezoelectric layer including a top surface and a bottom surface; a signal pad electrically coupled to the top surface of the piezoelectric layer; and a ground pad electrically coupled to the bottom surface of the piezoelectric layer, the signal pad and the ground pad located in the same plane and separated by a groove, the groove configured to electrically couple the signal pad and the ground pad to a cable. In a first example of the embodiment, the groove is configured to couple the signal pad and ground pad to the cable through a flex attachment having a distal end and a proximal end, the distal end inserted into the groove and the proximal end coupled to the cable. A second example of the embodiment optionally includes the first example and further includes, the flex attachment has a first conductive layer in contact with the signal pad and a second conductive layer in contact with the ground pad, and the first conductive layer is insulated from the second conductive layer by a non-conductive layer. A third example of the embodiment optionally includes one or more of the first and second examples, and further includes, a backing layer having a top surface in contact with the bottom surface of the piezoelectric layer; and a matching layer having a top surface and a bottom surface, the top surface of the matching layer plated with a conductive coating, the bottom surface of the matching layer in contact with the top surface of the piezoelectric layer. A fourth example of the embodiment optionally includes one or more of the first through third examples, and further includes, a conductive via extending vertically from the conductive coating to the signal pad, and a non-conductive base package between the conductive via and the piezoelectric layer. A fifth example of the embodiment optionally includes one or more of the first through fourth examples, and further includes, a first conductive base package extending vertically from the conductive coating to the signal pad, and a non-conductive trench between the first conductive base package and the piezoelectric layer. A sixth example of the embodiment optionally includes one or more of the first through fifth examples, and further includes, a second conductive base package coupled between the backing layer and the ground pad, the second base package separated from the first base package by the non-conductive trench.

In another embodiment, a method comprises laminating a first comb structure and a second comb structure into an acoustic stack, the first comb structure having fins including a piezoelectric layer intermediate a matching layer and a backing layer, the second comb structure having fins and kerfs; plating a first conductive layer over a top surface of the acoustic stack; plating a second conductive layer over a bottom surface of the acoustic stack; cutting a groove through the second conductive layer; dicing the cut acoustic stack into an ultrasound transducer having a back face including a signal pad and a ground pad separated by the groove; and inserting a distal distal end of a flex attachment into the groove, the flex attachment having a proximal end configured to electrically couple to a processor. In a first example of the embodiment, the method further includes manufacturing the second comb structure by forming conductive vias in a non-conductive substrate. A second example of the embodiment optionally includes the first example and further includes manufacturing the second comb structure by forming a non-conductive trench in a conductive substrate.

As used herein, an element or step recited in the singular and proceeded with the word “a” or “an” should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to “one embodiment” of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments “comprising,” “including,” or “having” an element or a plurality of elements having a particular property may include additional such elements not having that property. The terms “including” and “in which” are used as the plain-language equivalents of the respective terms “comprising” and “wherein.” Moreover, the terms “first,” “second,” and “third,” etc. are used merely as labels, and are not intended to impose numerical requirements or a particular positional order on their objects.

This written description uses examples to disclose the invention, including the best mode, and also to enable a person of ordinary skill in the relevant art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

The invention claimed is:

1. An ultrasound transducer, comprising:

a front face;

a back face parallel to the front face, the back face having a signal pad and a ground pad disposed on the back face, and a groove in the back face disposed between the signal pad and the ground pad on the back face; and

a piezoelectric layer having a top surface electrically coupled to the signal pad and a bottom surface electrically coupled to the ground pad.

2. The ultrasound transducer of claim **1**, further comprising a flex attachment having a first conductive layer and a second conductive layer separated by a non-conductive layer, the first conductive layer in contact with the signal pad, the second conductive layer in contact with the ground pad, the piezoelectric layer intermediate a matching layer and a backing layer.

3. The ultrasound transducer of claim **2**, further comprising a first conductive via extending vertically from the signal pad to a conductive coating over a top surface of the matching layer, and the signal pad is electrically coupled to the top surface of the piezoelectric layer through the first conductive via, the conductive coating, and the matching layer.

4. The ultrasound transducer of claim **3**, further comprising a second conductive via, and the ground pad is electrically coupled to the bottom surface of the piezoelectric layer through the second conductive via and the backing layer.

5. The ultrasound transducer of claim **4**, further comprising a non-conductive base package separating the first conductive via from the second conductive via.

6. The ultrasound transducer of claim **5**, wherein the second conductive via is surrounded by the non-conductive base package.

7. The ultrasound transducer of claim **2**, further comprising a first conductive base package extending vertically from the signal pad to a conductive coating over the matching layer, and the signal pad is electrically coupled to the top surface of the piezoelectric layer through the first conductive base package, the conductive coating, and the matching layer.

8. The ultrasound transducer of claim **7**, further comprising a second conductive base package extending vertically from the ground pad to a back surface of the backing layer, and the ground pad is electrically coupled to the bottom surface of the piezoelectric layer through the second conductive base package and the backing layer.

9. The ultrasound transducer of claim **8**, further comprising a non-conductive trench between the first conductive base package and the second conductive base package.

10. The ultrasound transducer of claim **1**, further comprising a flat flex pad with circuit printed on one surface, wherein the back face of the transducer is surface mounted on top of the flex pad.

11. An ultrasound transducer assembly, comprising:

a piezoelectric layer including a top surface and a bottom surface;

a signal pad electrically coupled to the top surface of the piezoelectric layer; and

a ground pad disposed on the bottom surface of the piezoelectric layer, the signal pad and the ground pad located in the same plane and separated by a groove in the bottom surface, the groove configured to electrically couple the signal pad and the ground pad to a cable.

12. The ultrasound transducer assembly of claim **11**, wherein the groove is configured to couple the signal pad and the ground pad to the cable through a flex attachment having a distal end and a proximal end, the distal end inserted into the groove and the proximal end coupled to the cable.

13. The ultrasound transducer assembly of claim **12**, wherein the flex attachment has a first conductive layer in contact with the signal pad and a second conductive layer in contact with the ground pad, and the first conductive layer is insulated from the second conductive layer by a non-conductive layer.

14. The ultrasound transducer assembly of claim **11**, further comprising a backing layer having a top surface in contact with the bottom surface of the piezoelectric layer; and a matching layer having a top surface and a bottom surface, the top surface of the matching layer plated with a conductive coating, the bottom surface of the matching layer in contact with the top surface of the piezoelectric layer.

15. The ultrasound transducer assembly of claim **14**, further comprising a conductive via extending vertically from the conductive coating to the signal pad, and a non-conductive base package between the conductive via and the piezoelectric layer.

16. The ultrasound transducer assembly of claim **14**, further comprising a first conductive base package extending vertically from the conductive coating to the signal pad, and a non-conductive trench between the first conductive base package and the piezoelectric layer.

17. The ultrasound transducer assembly of claim **16**, further comprising a second conductive base package coupled between the backing layer and the ground pad, the second conductive base package separated from the first conductive base package by the non-conductive trench.

* * * * *

patsnap

专利名称(译)	超声换能器和晶片级背面附着方法		
公开(公告)号	US10561398	公开(公告)日	2020-02-18
申请号	US15/385671	申请日	2016-12-20
[标]申请(专利权)人(译)	通用电气公司		
申请(专利权)人(译)	通用电气公司		
当前申请(专利权)人(译)	通用电气公司		
[标]发明人	DALOZ FLAVIEN BARRETT JASON DA CRUZ EDOUARD MALACRIDA JEAN PIERRE		
发明人	DALOZ, FLAVIEN BARRETT, JASON DA CRUZ, EDOUARD MALACRIDA, JEAN PIERRE		
IPC分类号	H01L41/09 A61B8/00 B06B1/06 H01L41/313 H01L41/08 H01L41/338		
CPC分类号	H01L41/0815 A61B8/4483 H01L41/338 H01L41/313 B06B1/0644		
其他公开文献	US20180175278A1		
外部链接	Espacenet		

摘要(译)

提供了用于单元件超声换能器的方法和系统。 在一个实施例中，超声换能器包括正面，与正面平行的背面，压电层，该压电层具有电连接到信号垫的顶表面和电连接到接地垫的底表面。 这样，换能器可以牢固地工作，并且可以自动安装到成像探头。