(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 414 738 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: **22.03.2006 Bulletin 2006/12**

(21) Application number: **02758677.5**

(22) Date of filing: **26.07.2002**

(51) Int Cl.:
***B81B 7/00*** *(2006.01)* ***B06B 1/00*** *(2006.01)*
***B81B 3/00*** *(2006.01)*

(86) International application number:
**PCT/IB2002/003144**

(87) International publication number:
**WO 2003/011748 (13.02.2003 Gazette 2003/07)**

(54) **MICRO-MACHINED ULTRASONIC TRANSDUCER (MUT) SUBSTRATE THAT LIMITS THE LATERAL PROPAGATION OF ACOUSTIC ENERGY**

SUBSTRAT FÜR MIKROBEARBEITETE ULTRASCHALLWANDLERANORDNUNG, DAS DIE SEITENÜBERTRAGUNG VON SCHALLENERGIE BEGRENZT

SUBSTRAT A TRANSDUCTEUR ULTRASONIQUE MICRO-USINE (MUT) QUI LIMITE LA PROPAGATION LATERALE D'ENERGIE ACOUSTIQUE

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR**

(30) Priority: **31.07.2001 US 919250**

(43) Date of publication of application:
**06.05.2004 Bulletin 2004/19**

(73) Proprietor: **Koninklijke Philips Electronics N.V.**
**5621 BA Eindhoven (NL)**

(72) Inventor: **MILLER, David, G.**
**NL-5656 AA Eindhoven (NL)**

(74) Representative: **Charpail, François et al**
**Philips Intellectual Property & Standards,**
**156 Boulevard Haussmann**
**75008 Paris (FR)**

(56) References cited:
**EP-A- 0 559 963** **WO-A-01/23105**
**US-A- 5 855 049**

- **PATENT ABSTRACTS OF JAPAN vol. 015, no. 417 (E-1125), 23 October 1991 (1991-10-23) -& JP 03 172099 A (NIPPON DEMPA KOGYO CO LTD), 25 July 1991 (1991-07-25)**
- **PATENT ABSTRACTS OF JAPAN vol. 006, no. 205 (E-136), 16 October 1982 (1982-10-16) -& JP 57 112198 A (FUJITSU KK), 13 July 1982 (1982-07-13)**





Printed by Jouve, 75001 PARIS (FR)

## Description

### TECHNICAL FIELD

**[0001]** The present invention relates generally to ultrasonic transducers, and, more particularly, to a micro-machined ultrasonic transducer (MUT) substrate for limiting the lateral propagation of acoustic energy.

### BACKGROUND OF THE INVENTION

**[0002]** Ultrasonic transducers have been available for quite some time and are particularly useful for non-invasive medical diagnostic imaging. Ultrasonic transducers are typically formed of either piezoelectric elements or of micro-machined ultrasonic transducer (MUT) elements. The piezoelectric elements typically are made of a piezoelectric ceramic such as lead-zirconate-titanate (abbreviated as PZT), with a plurality of elements being arranged to form a transducer. A MUT is formed using known semiconductor manufacturing techniques resulting in a capacitive ultrasonic transducer cell that comprises, in essence, a flexible membrane supported around its edges over a silicon substrate. The membrane is supported by the substrate and forms a cavity. By applying contact material, in the form of electrodes, to the membrane, or a portion of the membrane, and to the base of the cavity in the silicon substrate, and then by applying appropriate voltage signals to the electrodes, the MUT may be electrically energized to produce an appropriate ultrasonic wave. Similarly, when electrically biased, the membrane of the MUT may be used to receive ultrasonic signals by capturing reflected ultrasonic energy and transforming that energy into movement of the electrically biased membrane, which then generates a receive signal.

**[0003]** Typical ultrasonic transducers are described in EP 0 559 963 and WO01/23105.

**[0004]** The MUT cells are typically fabricated on a suitable substrate material, such as silicon (Si). A plurality of MUT cells are electrically connected forming a MUT element. Typically, many hundreds or thousands of MUT elements comprise an ultrasonic transducer array. The transducer elements in the array may be combined with control circuitry forming a transducer assembly, which is then further assembled into a housing possibly including additional control electronics, in the form of electronic circuit boards, the combination of which forms an ultrasonic probe. This ultrasonic probe, which may include various acoustic matching layers, backing layers, and de-matching layers, may then be used to send and receive ultrasonic signals through body tissue.

**[0005]** Unfortunately, the substrate material on which the MUT elements are formed has a propensity to couple acoustic energy from one MUT element to another. This occurs because the substrate material is typically monolithic in structure and acoustic energy from one MUT element is easily coupled through the substrate to adjoining MUT elements. Therefore it would be desirable to have a way to fabricate a MUT substrate that reduces or eliminates the lateral propagation of acoustic energy.

### SUMMARY

**[0006]** The invention is a MUT substrate that reduces or substantially eliminates the lateral propagation of acoustic energy. The MUT substrate includes holes, commonly referred to as vias, formed in the substrate and proximate to a micro-machined ultrasonic transducer (MUT) element. The vias in the MUT substrate reduce or eliminate the propagation of acoustic energy traveling laterally in the MUT substrate. The vias can be doped to provide an electrical connection between the MUT element and circuitry present on the surface of an integrated circuit substrate over which the MUT substrate is attached.

**[0007]** Other systems, methods, features, and advantages of the invention will be or will become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** The present invention, as defined in the claims, can be better understood with reference to the following drawings. The components within the drawings are not necessarily to scale relative to each other, emphasis instead being placed upon clearly illustrating the principles of the present invention.

FIG. 1 is a cross-sectional schematic view of an ultrasonic transducer including a MUT element.

FIG. 2 is a cross-sectional schematic view of a MUT transducer assembly fabricated in accordance with an aspect of the invention.

FIG. 3 is a cross-sectional schematic view illustrating an alternative of the MUT transducer assembly of FIG. 2.

FIG. 4 is a cross-section schematic view of another alternative embodiment of the MUT transducer assembly of FIG. 2.

FIG. 5 is another alternative embodiment of the MUT transducer assembly of FIG. 2.

### DETAILED DESCRIPTION OF THE INVENTION

**[0009]** The invention to be described hereafter is applicable to micro-machined ultrasonic transducer (MUT) elements connected to a substrate on which an integrated circuit (IC) can be formed.

**[0010]** FIG. 1 is a simplified cross-sectional schematic view of an ultrasonic transducer 100 including a MUT element. The ultrasonic transducer 100 includes a MUT element 110 formed on the surface of a MUT substrate 120. Preferably, the MUT substrate 120 is silicon, but it can alternatively be any other appropriate material over which a MUT element can be formed. To form the MUT element 110, a conductive layer 116 is formed on a surface of the MUT substrate as shown. The conductive layer 116 can be constructed using, for example, aluminum, gold or doped silicon. A layer of a flexible membrane 118 is deposited over the MUT substrate 120 and the conductive layer 116 so that a gap 114 is formed as shown. The flexible membrane 118 can be constructed using, for example, silicon *nitride* ($Si_3N_4$) or silicon dioxide ($SiO_2$). The gap 114 can be formed to contain a vacuum or can be formed to contain a gas at atmospheric pressure. A conductive layer 112 is grown over the portion of the flexible membrane 118 that resides over the gap 114, thus forming the MUT element 110.

**[0011]** During a transmit pulse, the flexible membrane 114 deforms in response to electrical stimulus applied to the conductors 112 and 116. The deformation causes acoustic energy to be generated and transmitted both away from the MUT substrate 120 and into the MUT substrate 120. During receive operation, the flexible membrane 118 is electrically biased using electrical stimulus applied through the conductors 112 and 116. When electrically biased, the flexible membrane 118 produces a change in voltage that generates an electrical signal in response to acoustic energy received by the MUT element 110.

**[0012]** The MUT substrate 120 is joined to an integrated circuit (IC) 130 formed on the surface of IC substrate 140. In accordance with an aspect of the invention, the MUT substrate 120 includes a plurality of holes, commonly referred to as vias, formed through the MUT substrate. The vias are formed proximate to the MUT element 110 and reduce or eliminate the lateral propagation of acoustic energy in the MUT substrate 120.

**[0013]** A number of different methodologies can be used to join the MUT substrate 120 to the IC 140, many of which are disclosed in commonly assigned U. S. Patent Application entitled "System for Attaching an Acoustic Element to an Integrated Circuit," filed on even date herewith.

**[0014]** A layer of backing 150 can be applied behind the IC substrate 140. The backing 150 acts as an acoustic absorption material. The backing 150 is bonded to the IC substrate 140 using, for example, a bonding material that is preferably acoustically transparent.

**[0015]** FIG. 2 is a cross-sectional schematic view of a MUT assembly 200 fabricated in accordance with an aspect of the invention. The MUT assembly 200 includes a MUT substrate 220 upon which a plurality of MUT cells, an exemplar one of which is illustrated using reference number 216, are formed. A plurality of MUT cells 216 form a MUT element 210. In this example, four MUT cells 216 combine to form MUT element 210. The MUT element 210 resides on a major surface of the MUT substrate 220 and is shown exaggerated in profile. In accordance with an aspect of the invention, a plurality of holes, commonly referred to as vias, an exemplar one of which is illustrated using reference numeral 215, are etched through the MUT substrate 220 proximate to each MUT cell 216. For example, as shown in FIG. 2, the four MUT cells 216 are each surrounded by four vias 215. Each via 215 is etched completely through the MUT substrate 220, thereby creating voids in the MUT substrate 220 that reduce or eliminate the propagation of acoustic energy waves traveling laterally through the MUT substrate 220. By reducing these lateral waves, acoustic cross-talk between the MUT elements 210 can be significantly reduced or eliminated.

**[0016]** In another aspect of the invention, each of the vias 215 can be doped to be electrically conductive. By making the vias electrically conductive, circuitry located on the surface of an integrated circuit (not shown in FIG. 2) that is applied to the back surface 222 of the MUT substrate 220 can be electrically connected through the conductive via 215 to each MUT element 210. Although omitted for clarity, each of the vias 215 can be connected to the MUT element 210, thereby creating an electrical connection between the MUT element 210 and the vias 215. In this manner, the vias 215 are used for electrical conduction and to reduce or substantially eliminate acoustic energy traveling laterally in the substrate 220.

**[0017]** The vias can be etched into the MUT substrate 220 from both surfaces 221 and 222. Placing the vias 215 at the respective corners of each MUT element 210 allows the number of MUT cells 216 on the surface 221 to be maximized. Furthermore, as illustrated in FIG. 2, the diameter of the via 215 towards the surface 221 is smaller than the diameter of the via 215 towards the surface 222 of MUT substrate 220. In this manner, the larger diameter portion of the via 215 towards surface 222 can be used to reduce acoustic energy propagating laterally in the MUT substrate 220, while the diameter of the via 215 towards the surface 221 of the MUT substrate 220 can be kept as small as possible. The vias 215 can be etched by using, for example, deep reactive ion etching from the surface 222 to produce a tapered variation in the via diameter as described above. As shown in FIG. 2, the taper of the via 215 is parabolic with the larger diameter towards the surface 222. Furthermore, blind vias or counterbores can also be used to further reduce acoustic energy traveling laterally in the MUT substrate 220.

**[0018]** FIG. 3 is a cross-sectional schematic view illustrating an alternative of the MUT assembly of FIG. 2. The MUT assembly 300 of FIG. 3 includes a MUT substrate 305 and a MUT substrate 325 bonded "back-to-back" along section line 335. Prior to bonding the two MUT substrates together, the vias 315 are etched into MUT substrate 305 and the vias 316 are etched into MUT substrate 325. By etching the vias into the two thinner substrates 305 and 325, greater precision of the size of the via can be obtained. For example, the vias 315 are etched into the MUT substrate 305 from surfaces 321 and 322. Similarly, the vias 316 are etched into MUT substrate 325 from surfaces 326 and 327. By etching the vias 315 and 316 into two substrates 305 and 325, respectively, each of which are thinner than substrate 220 of FIG. 2, the vias 315 and 316 can be formed with greater precision than the vias 215 of FIG. 2. For example, the position and diameter of each of the vias 315 and 316 can be precisely controlled. Furthermore, the vias 315 and 316 can be tapered as mentioned above.

**[0019]** After the vias are etched, the surface 322 of MUT substrate 305 and the surface 327 of MUT substrate 325 are lapped to reduce the thickness of the substrates 305 and 327 to a desired thickness, and are then bonded together along section line 335. The two MUT substrates 305 and 325 can be anodically bonded, fusion bonded, or brazed together. In this manner, small diameter vias will appear on the surface 321 of MUT substrate 305 and on the surface 326 of MUT substrate 325.

**[0020]** FIG. 4 is a cross-section schematic view of another alternative embodiment of the MUT assembly 200 of FIG. 2. The MUT assembly 400 of FIG. 4 includes MUT substrate 405, through which vias 415 are etched in similar manner to that described above with respect to FIG. 2. However, the MUT assembly 400 includes an additional substrate 450, which can be fabricated using the same material as MUT substrate 405, bonded to the MUT substrate 405. The MUT element 410 is formed on the additional substrate 450. The additional substrate 450 includes small vias 455 etched through the additional substrate 450 at locations corresponding to the locations of vias 415 in MUT substrate 405. The vias 455 are generally smaller in diameter than the vias 415. In this manner, a greater variation between the size of the via 415 at the surface 422 and the size of the via 455 at the surface 421 can be obtained.

**[0021]** FIG. 5 is another alternative embodiment of the MUT assembly 200 of FIG. 2. The MUT assembly 500 of FIG. 5 includes vias 515 that are etched into MUT substrate 505 from both surface 521 and surface 522. The via portion 525 etched from surface 521 meets the via 515 etched from surface 522 partway through the substrate 505 approximately as shown. Etching the vias from both surfaces 521 and 522 of the MUT substrate 505, enables the diameter of the via to be more precisely controlled.

**[0022]** It will be apparent to those skilled in the art that many modifications and variations may be made to the present invention, as set forth above, without departing substantially from the principles of the present invention. For example, the present invention can be used with MUT transducer elements and a plurality of different substrate materials. All such modifications and variations are intended to be included herein.

**Claims**

1. An ultrasonic transducer, comprising:

   - a first substrate (220,305,405, 505) comprising a first surface (221, 321, 421, 521) and a second surface (222, 326, 422, 522), the first surface being a front surface, the second surface being a back surface opposite to the front surface; and
   - a plurality of micro-machined ultrasonic transducer (210, 310, 410, 510) elements formed on the first surface, each micro-machined ultrasonic transducer element comprising at least one micro-machined ultrasonic transducer cell (216);

   wherein the ultrasonic transducer further comprises:

   - a plurality of vias (215, 315, 316, 415, 455, 515, 525) for reducing the propagation of acoustic energy travelling laterally in the first substrate extending through the first substrate and proximate to each micro-machined ultrasonic transducer element, so as to surround the at least one micro-machined ultrasonic transducer cell, the vias having a diameter varying through the first substrate, the diameter being smaller towards the first surface.

2. The transducer of claim 1, wherein the vias (215, 315, 316, 415, 455, 515, 525) are etched into the first substrate (220,305,405,505).

3. The transducer of claim 2, wherein the vias (215, 315, 316, 415, 455, 515, 525) are etched into the first surface (221, 321, 421, 521) of the first substrate and the second surface (222, 326, 422, 522) of the first substrate.

4. The transducer of claim 3, wherein the vias (215, 315, 316, 415, 455, 515, 525) taper between the second surface (222, 326, 422, 522) of the first substrate and the first surface (221, 321, 421, 521) of the first substrate.

5. The transducer of claim 1, wherein:

   - the first substrate comprises a first (305) and a second (325) portion, each portion comprising a first portion surface (321 ; 326) and an opposite second portion surface (322 ; 327), the second portion surface of the first and the second portion being joined together so that the first portion surface (321) of the first portion (305) defines the first surface and the first portion surface (326) of the second portion (325) defines the second surface ; and
   - the vias (315 ; 316) are etched into each portion

(305 ; 325) so that each via is larger in diameter at the second portion surface (322 ; 327) of each portion than at the first portion surface (321 ; 326) of each portion.

6. The transducer of claim 2, further comprising a second substrate (450) joined to the first substrate (405) and wherein the vias (455) are etched into the second substrate.

7. The transducer of claim 2, wherein the vias include a first portion (525) having a first diameter extending from the first surface (521) of the first substrate (505) toward the second surface (522) of the first substrate and a second portion (515) having a varying diameter extending from the second surface (522) of the first substrate toward the first surface (521) of the first substrate.

8. A method for reducing the lateral propagation of acoustic energy in an ultrasonic transducer, the method comprising the step of:

   - forming a plurality of micro-machined ultrasonic transducer elements on a first substrate, the first substrate comprising a first surface and a second surface, the first surface being a front surface, the second surface being a back surface opposite to the front surface, each micro-machined ultrasonic transducer element comprising at least one micro-machined ultrasonic transducer cell formed on the first surface;

   wherein the method further comprises the step of

   - forming a plurality of vias for reducing the lateral propagation of acoustic energy in the first substrate, said vias being formed through the first substrate and proximate to each micro-machined ultrasonic transducer element so as to surround the at least one micro-machined ultrasonic transducer cell, each via having a diameter varying through the: first substrate, the diameter being smaller towards the first surface.

9. The method of claim 8, further comprising the step of etching the vias into the first substrate.

10. The method of claim 9, further comprising the step of etching the vias into the first surface of the first substrate and the second surface of the first substrate.

11. The method of claim 10, further comprising the step of tapering the vias between the second surface of the first substrate and the first surface of the first substrate.

12. The method of claim 8, further comprising the steps of:

   - forming the first substrate in a first and a second portion, each portion comprising a first portion surface and an opposite second portion surface;
   - etching the vias into each portion so that each via is larger at the second portion surface of each portion than at the first portion surface of each portion; and
   - joining the second portion surface of the first and the second portion together so that the first portion surface of the first portion defines the first surface and the first portion surface of the second portion defines the second surface.

13. The method of claim 11, further comprising the steps of:

   - forming a second substrate associated with the first substrate; and
   - etching the vias into the second substrate.

14. The method of claim 11, further comprising the steps of:

   - forming the vias to include a first portion having a first diameter extending from the first surface of the first substrate toward the second surface of the first substrate; and
   - forming the vias to include a second portion having a varying diameter extending from the second surface of the first substrate toward the first surface of the first substrate.

**Revendications**

1. Transducteur ultrasonique, comprenant :

   - un premier substrat (220, 305, 405, 505) comprenant une première surface (221, 321, 421, 521) et une deuxième surface (222, 326, 422, 522), la première surface étant une surface avant, la deuxième surface étant une surface arrière opposée à la surface avant ; et
   - une pluralité d'éléments à transducteur ultrasoniques micro-usinés (210, 310, 410, 510) formés sur la première surface, chaque élément à transducteur ultrasonique micro-usiné comprenant au moins une cellule à transducteur ultrasonique micro-usinée (216) ;

   dans lequel le transducteur ultrasonique comprend en outre :

   - une pluralité de trous de connexion (215,315,316,415,455,515, 525) servant à réduire la propagation d'énergie acoustique se déplaçant latéralement dans le premier substrat qui s'étend à travers le premier substrat et près de chaque élément à transducteur ultrasonique micro-usiné, de façon à entourer ladite au moins une cellule à transducteur ultrasonique micro-usinée, les trous de connexion présentant un diamètre qui varie à travers le premier substrat, le diamètre étant plus petit dans la direction de la première surface.

**2.** Transducteur selon la revendication 1, dans lequel les trous de connexion (215,315,316,415,455,515, 525) sont réalisés par décapage dans le premier substrat (220, 305, 405, 505).

**3.** Transducteur selon la revendication 2, dans lequel les trous de connexion (215, 315, 316, 415, 455, 515, 525) sont réalisés par décapage dans la première surface (221, 321, 421, 521) du premier substrat et la deuxième surface (222, 326, 422, 522) du premier substrat.

**4.** Transducteur selon la revendication 3, dans lequel les trous de connexion (215, 315, 316, 415, 455, 515, 525) sont coniques entre la deuxième surface (222, 326, 422, 522) du premier substrat et la première surface (221, 321, 421, 521) du premier substrat.

**5.** Transducteur selon la revendication 1, dans lequel :

- le premier substrat comprend une première partie (305) et une deuxième partie (325), chaque partie comprenant une première surface de partie (321 ; 326) et une deuxième surface de partie opposée (322 ; 327), la deuxième surface de partie de la première partie et de la deuxième partie étant réunies ensemble de façon que la première surface de partie (321) de la première partie (305) définisse la première surface et la première surface de partie (326) de la deuxième partie (325) définisse la deuxième surface ; et
- les trous de connexion (315 ; 316) sont réalisés par décapage dans chaque partie (305 ; 325) de façon que chaque trou de connexion présente un plus grand diamètre à la deuxième surface de partie (322 ; 327) de chaque partie qu'à la première surface de partie (321 ; 326) de chaque partie.

**6.** Transducteur selon la revendication 2 comprenant en outre un deuxième substrat (450) qui est réuni au premier substrat (405) et dans lequel les trous de connexion (455) sont réalisés par décapage dans le deuxième substrat.

**7.** Transducteur selon la revendication 2, dans lequel les trous de connexion comprennent une première partie (525) présentant un premier diamètre s'étendant à partir de la première surface (521) du premier substrat (505) dans la direction de la deuxième surface (522) du premier substrat et une deuxième partie (515) présentant un diamètre variable s'étendant à partir de la deuxième surface (522) du premier substrat dans la direction de la première surface (521) du premier substrat.

**8.** Procédé servant à réduire la propagation latérale d'énergie acoustique dans un transducteur ultrasonique, procédé qui comprend les étapes de ;

- la formation d'une pluralité d'éléments à transducteur ultrasoniques micro-usinés sur un premier substrat, le premier substrat comprenant une première surface et une deuxième surface, la première surface étant une surface avant, la deuxième surface étant une surface arrière opposée à la surface avant, chaque élément à transducteur ultrasonique micro-usiné comprenant au moins une cellule à transducteur ultrasonique micro-usinée formée sur la première surface ;

dans lequel le procédé comprend en outre les étapes de :

- la formation d'une pluralité de trous de connexion servant la réduire la propagation latérale d'énergie acoustique dans le premier substrat, lesdits trous de connexion étant formés à travers la premier substrat et près de chaque élément à transducteur ultrasonique micro-usiné de façon à entourer ladite au moins une cellule à transducteur ultrasonique micro-usinée, chaque trou de connexion présentant un diamètre qui varie à travers le premier substrat, le diamètre étant plus petit dans la direction de la première surface .

**9.** Procédé selon la revendication 8, comprenant en outre l'étape de la réalisation par décapage des trous de connexion dans le premier substrat.

**10.** Procédé selon la revendication 9, comprenant en outre l'étape de la réalisation par décapage des trous de connexion dans la première surface du premier substrat et la deuxième surface du premier substrat.

**11.** Procédé selon la revendication 10, comprenant en outre l'étape de rendre les trous de connexion coniques entre la deuxième surface du premier substrat et la première surface du premier substrat.

**12.** Procédé selon la revendication 88, comprenant en outre les étapes de :

- la formation du premier substrat dans une première partie et une deuxième partie, chaque partie comprenant une première surface de partie et un deuxième surface de partie opposée ;
- la réalisation par décapage des trous de connexion dans chaque partie de façon que chaque trou de connexion soit plus grand à la deuxième surface de partie de chaque partie qu'à la première surface de partie de chaque partie ; et
- la réunion de la deuxième surface de partie de la première partie et de la deuxième partie ensemble de façon que la première surface de partie de la première partie définisse la première surface et la première surface de partie de la deuxième partie définisse la deuxième surface.

**13.** Procédé selon la revendication 11, comprenant en outre les étapes de :

- la formation d'un deuxième substrat associé au premier substrat ; et
- la réalisation par décapage des trous de connexion dans le deuxième substrat.

**14.** Procédé selon la revendication 11, comprenant en outre les étapes de :

- la formation des trous de connexion afin de comprendre une première partie présentant un premier diamètre qui s'étend à partir de la première surface du premier substrat dans la direction de la deuxième surface du premier substrat ; et
- la formation des trous de connexion afin de comprendre une deuxième partie présentant un diamètre variable qui s'étend à partir de la deuxième surface du premier substrat dans la direction de la première surface du premier substrat.

**Patentansprüche**

**1.** Ultraschallwandler mit

- einem ersten Substrat (220, 305, 405, 505) mit einer ersten Oberfläche (221, 321, 421, 521) und einer zweiten Oberfläche (222, 326, 422, 522), wobei die erste Oberfläche eine Frontfläche ist und die zweite Oberfläche eine rückseitige, der Frontfläche gegenüberliegende Oberfläche ist; und
- einer Vielzahl von mikrobearbeiteten Ultraschallwandler-Elementen (210, 310, 410, 510), die auf der ersten Oberfläche gebildet sind, wobei jedes mikrobearbeitete Ultraschallwandler-Element mindestens eine mikrobearbeitete Ultraschallwandler-Zelle (216) umfasst;

wobei der Ultraschallwandler weiterhin Folgendes umfasst:

- eine Vielzahl von Durchgangslöchern (215, 315, 316, 415, 455, 515, 525) zur Reduzierung der seitlichen Ausbreitung von Schallenergie in dem ersten Substrat, welche durch das erste Substrat und proximal zu jedem mikrobearbeiteten Ultraschallwandler-Element verlaufen, so dass sie die mindestens eine mikrobearbeitete Ultraschallwandler-Zelle umgeben, wobei die Durchgangslöcher einen Durchmesser aufweisen, der sich durch das erste Substrat verändert, wobei der Durchmesser zu der ersten Oberfläche hin kleiner wird.

**2.** Wandler nach Anspruch 1, wobei die Durchgangslöcher (215, 315, 316, 415, 455, 515, 525) in das erste Substrat (220, 305, 405, 505) geätzt sind.

**3.** Wandler nach Anspruch 2, wobei die Durchgangslöcher (215, 315, 316, 415, 455, 515, 525) in die erste Oberfläche (221, 321, 421, 521) des ersten Substrats und in die zweite Oberfläche (222, 326, 422, 522) des ersten Substrats geätzt sind.

**4.** Wandler nach Anspruch 3, wobei sich die Durchgangslöcher (215, 315, 316, 415, 455, 515, 525) zwischen der zweiten Oberfläche (222, 326, 422, 522) des ersten Substrats und der ersten Oberfläche (221, 321, 421, 521) des ersten Substrats verjüngen.

**5.** Wandler nach Anspruch 1, wobei

- das erste Substrat einen ersten (305) und einen zweiten (325) Teil umfasst und jeder Teil eine erste Teiloberfläche (321; 326) und eine gegenüberliegende zweite Teiloberfläche (322; 327) umfasst, wobei die zweite Teiloberfläche des ersten und des zweiten Teils zusammengefügt sind, so dass die erste Teiloberfläche (321) des ersten Teils (305) die erste Oberfläche definiert und die erste Teiloberfläche (326) des zweiten Teils (325) die zweite Oberfläche definiert; und
- die Durchgangslöcher (315; 316) in jeden Teil (305; 325) geätzt sind, so dass jedes Durchgangsloch bei der zweiten Teiloberfläche (322; 327) jedes Teils einen größeren Durchmesser aufweist als bei der ersten Teiloberfläche (321; 326) jedes Teils.

**6.** Wandler nach Anspruch 2, weiterhin umfassend ein zweites Substrat (450), das mit dem ersten Substrat (405) zusammengefügt ist und in dem die Durchgangslöcher (455) in das zweite Substrat geätzt sind.

**7.** Wandler nach Anspruch 2, wobei die Durchgangslöcher einen ersten Teil (525) mit einem ersten Durchmesser enthalten, der sich von der ersten Oberfläche (521) des ersten Substrats (505) zu der zweiten Oberfläche (522) des ersten Substrats hin erstreckt, und einen zweiten Teil (515) mit einem variierenden Durchmesser enthalten, der sich von der zweiten Oberfläche (522) des ersten Substrats zu der ersten Oberfläche (521) des ersten Substrats hin erstreckt.

**8.** Verfahren zum Reduzieren der seitlichen Ausbreitung von Schallenergie in einem Ultraschallwandler, wobei das Verfahren die folgenden Schritte umfasst:

- Bilden einer Vielzahl von mikrobearbeiteten Ultraschallwandler-Elementen auf einem ersten Substrat, wobei das erste Substrat eine erste Oberfläche und eine zweite Oberfläche umfasst, wobei die erste Oberfläche eine Frontfläche ist und die zweite Oberfläche eine rückseitige, der Frontfläche gegenüberliegende Oberfläche ist, wobei jedes mikrobearbeitete Ultraschallwandler-Element mindestens eine mikrobearbeitete Ultraschallwandler-Zelle umfasst, die auf der ersten Oberfläche gebildet wird;

wobei das Verfahren weiterhin den folgenden Schritt umfasst:

- Bilden einer Vielzahl von Durchgangslöchern zur Reduzierung der seitlichen Ausbreitung von Schallenergie in dem ersten Substrat, wobei die genannten Durchgangslöcher durch das erste Substrat und proximal zu jedem mikrobearbeiteten Ultraschallwandler-Element verlaufen, so dass sie die mindestens eine mikrobearbeitete Ultraschallwandler-Zelle umgeben, wobei jedes Durchgangsloch einen Durchmesser aufweist, der sich durch das erste Substrat verändert, wobei der Durchmesser zu der ersten Oberfläche hin kleiner wird.

**9.** Verfahren nach Anspruch 8, weiterhin den Schritt des Ätzens der Durchgangslöcher in das erste Substrat umfassend.

**10.** Verfahren nach Anspruch 9, weiterhin den Schritt des Ätzens der Durchgangslöcher in die erste Oberfläche des ersten Substrats und in die zweite Oberfläche des ersten Substrats umfassend.

**11.** Verfahren nach Anspruch 10, weiterhin den Schritt des Verjüngens der Durchgangslöcher zwischen der zweiten Oberfläche des ersten Substrats und der ersten Oberfläche des ersten Substrats umfassend.

**12.** Verfahren nach Anspruch 8, weiterhin die folgenden Schritte umfassend:

- Bilden des ersten Substrats in einem ersten und einem zweiten Teil, wobei jeder Teil eine ersten Teiloberfläche und eine gegenüberliegende zweite Teiloberfläche umfasst;
- Ätzen von Durchgangslöchern in jeden Teil, so dass jedes Durchgangsloch bei der zweiten Teiloberfläche jedes Teils größer ist als bei der ersten Teiloberfläche jedes Teils; und
- Zusammenfügen der zweiten Teiloberfläche des ersten und des zweiten Teils, so dass die erste Teiloberfläche des ersten Teils die erste Oberfläche definiert und die erste Teiloberfläche des zweiten Teils die zweite Oberfläche definiert.

**13.** Verfahren nach Anspruch 11, das weiterhin die folgenden Schritte umfasst:

- Bilden eines zweiten Substrats, das zu dem ersten Substrat gehört; und
- Ätzen der Durchgangslöcher in das zweite Substrat.

**14.** Verfahren nach Anspruch 11, das weiterhin die folgenden Schritte umfasst:

- Bilden der Durchgangslöcher, so dass sie einen ersten Teil mit einem ersten Durchmesser haben, der sich von der ersten Oberfläche des ersten Substrats zu der zweiten Oberfläche des ersten Substrats hin erstreckt; und
- Bilden der Durchgangslöcher, so dass sie einen zweiten Teil mit einem variierenden Durchmesser haben, der sich von der zweiten Oberfläche des ersten Substrats zu der ersten Oberfläche des ersten Substrats hin erstreckt.

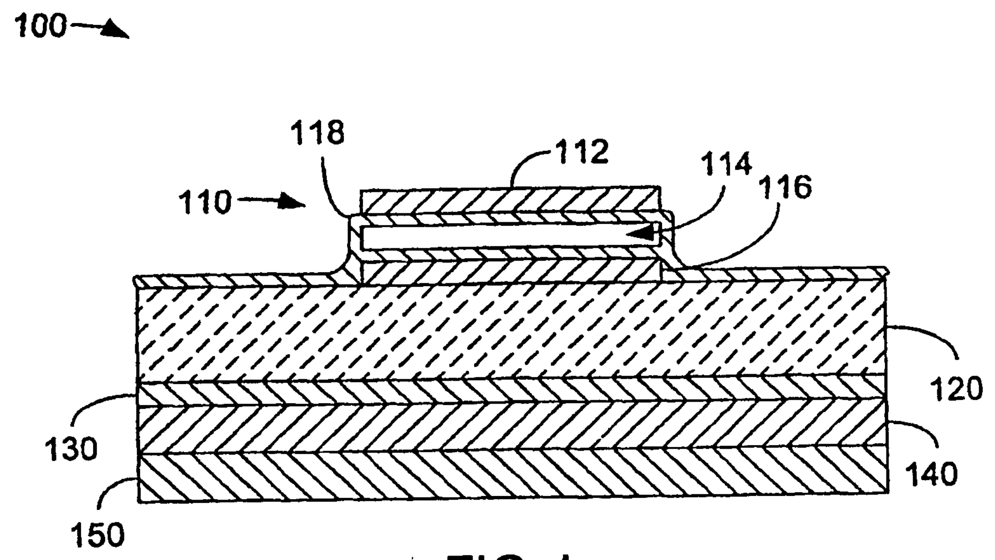


FIG.1

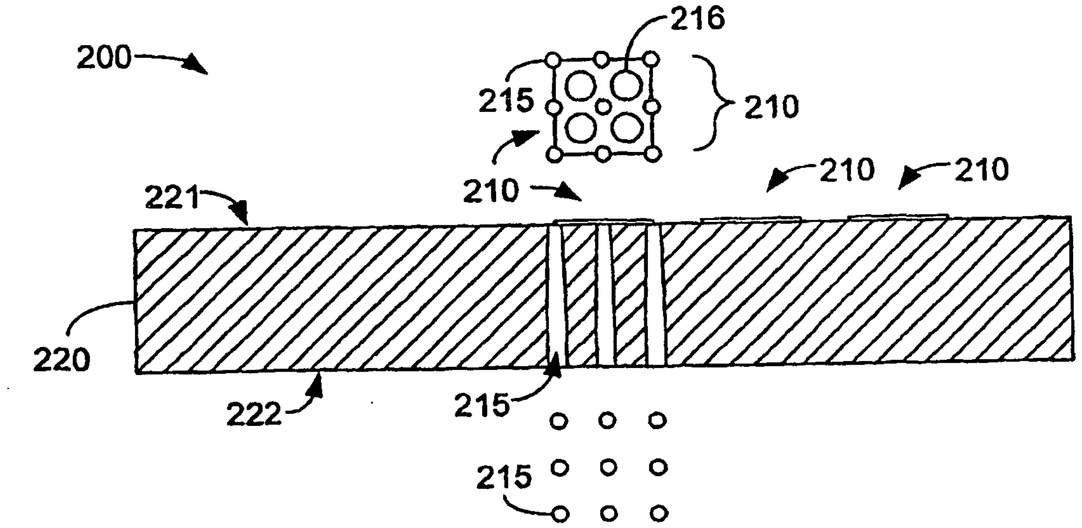


FIG.2

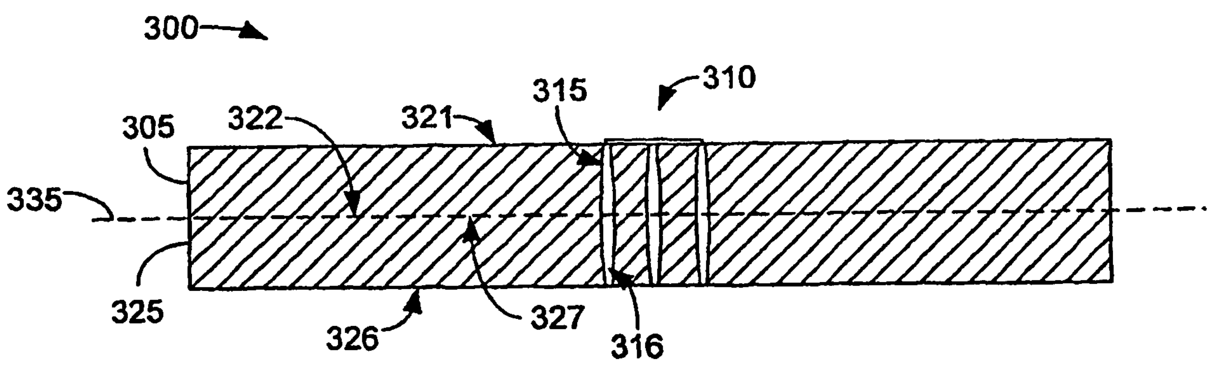


FIG.3

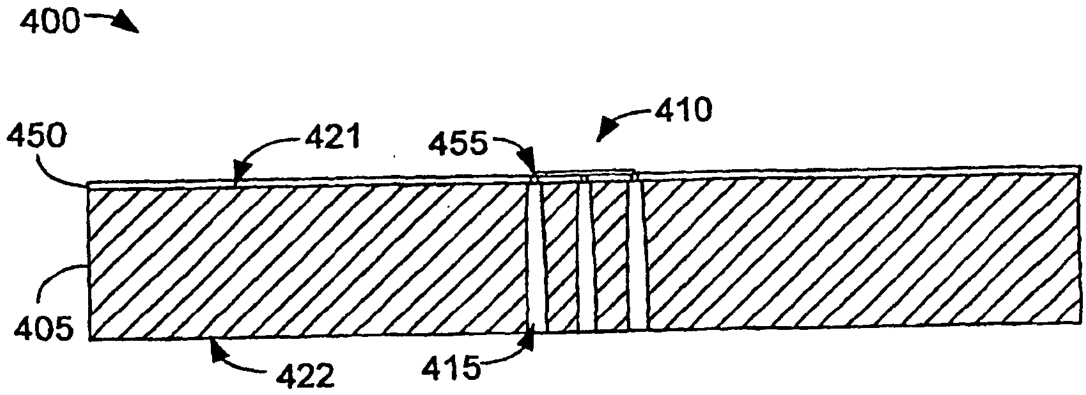


FIG.4

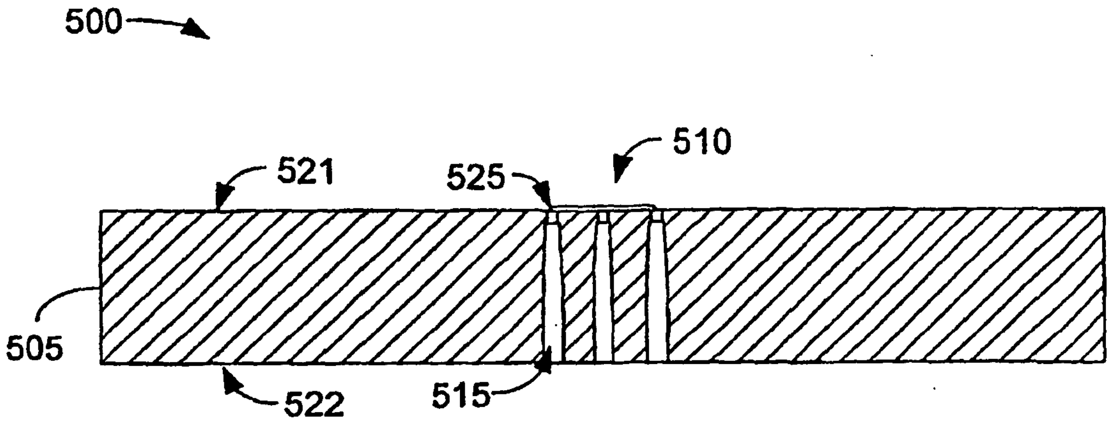


FIG.5

patsnap

| | | | |
|---|---|---|---|
| 专利名称(译) | 微机械超声换能器（MUT）基板，限制声能的横向传播 | | |
| 公开(公告)号 | EP1414738B1 | 公开(公告)日 | 2006-03-22 |
| 申请号 | EP2002758677 | 申请日 | 2002-07-26 |
| [标]申请(专利权)人(译) | 皇家飞利浦电子股份有限公司 | | |
| 申请(专利权)人(译) | 皇家飞利浦电子N.V. | | |
| 当前申请(专利权)人(译) | 皇家飞利浦电子N.V. | | |
| [标]发明人 | MILLER DAVID G | | |
| 发明人 | MILLER, DAVID, G. | | |
| IPC分类号 | B81B7/00 B06B1/00 B81B3/00 B81B1/00 A61B8/00 B06B1/02 B81C1/00 G10K11/00 H04R19/00 | | |
| CPC分类号 | G10K11/002 B06B1/0292 | | |
| 优先权 | 09/919250 2001-07-31 US | | |
| 其他公开文献 | EP1414738A2 | | |
| 外部链接 | Espacenet | | |


摘要(译)

减少或消除声能的横向传播的微机械超声换能器（MUT）基板包括形成在基板中并靠近MUT元件的孔，通常称为通孔。 MUT基板中的通孔减少或消除了在MUT基板中横向传播的声能的传播。可以掺杂通孔以在MUT元件和存在于集成电路基板表面上的电路之间提供电连接，MUT基板附着在该集成电路基板上。


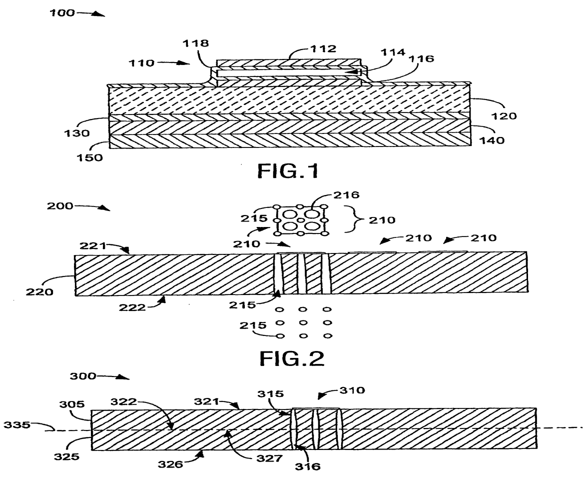

FIG.1 FIG.2 FIG.3