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(54) **ULTRASOUND ENDOSCOPE AND METHODS OF MANUFACTURE THEREOF**

ULTRASCHALLENDOSKOP UND HERSTELLUNGSVERFAHREN DAFÜR

ENDOSCOPE À ULTRASONS ET SES PROCÉDÉS DE FABRICATION

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(73) Proprietor: **Dalhousie University**
Halifax, NS B3H 4R2 (CA)

(72) Inventors:
- **BEZANSON, Andre B.**
  Halifax, Nova Scotia B3L 3Y3 (CA)
- **ADAMSON, Robert B.A.**
  Halifax, Nova Scotia B3L 1Z2 (CA)
- **BROWN, Jeremy A.**
  Halifax, Nova Scotia B3L 1Y1 (CA)

(74) Representative: **Lecomte & Partners**
P.O. Box 1623
1016 Luxembourg (LU)

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Description

BACKGROUND

[0001] Array-based endoscopic ultrasound systems operating at frequencies in the 1-10MHz range are used frequently for laparoscopic imaging where they provide fast scanning rates, dynamic focusing and beam steering. For endoscopic imaging applications requiring higher resolution such as intravascular, intracardiac, transurethral, trans-nasal and transtympanic imaging, ultrasound arrays have been challenging to manufacture owing the small element size, small element pitch and need to package the finished endoscope into a small enough package to enter the required lumens. These applications have, therefore, been served mainly by single element ultrasound endoscopes which, compared to arrays, suffer slower frame rates, a tradeoff between depth of field and lateral resolution and the necessity of having moving parts in the endoscope head which adds bulk and causes unwanted vibrations.

[0002] In recent years there has been significant progress in developing fully sampled forward looking high frequency linear array transducers. For most applications a phase-array endoscope would offer significant improvements over a single-element endoscope. However, although the elements are conventionally proportioned in these arrays, the overall packaging of the transducers remains relatively large. This limits the application of the arrays to topical use where images are generated from outside the body.

[0003] Piel et al. (US 6,541,896 B1) describes a combined acoustic backing and interconnect module for connecting an array of ultrasonic transducer elements to a multiplicity of conductors of a cable, utilizing the backing layer volume to extend a high density of interconnections perpendicular to the transducer array surface. The module is made by injecting flowable backfill material into a mold made up of a plurality of spacer plates having aligned channels, with interleaved flexible circuit boards. The backfill material is cured to form a backing layer which supports the flexible circuit boards in mutually parallel relationship. Excess flexible circuit material on one side of the backing layer is cut flush with the front face of the backing layer, leaving exposed ends of the conductive traces on the flexible circuit boards. The module is then laminated to a piezoelectric ceramic layer, and diced. The flexible circuit board conductive traces are aligned with, and electrically connected to, signal electrodes of the transducer elements. The other ends of the conductive traces on a fanout portion of the flexible circuit board are connected to the cable.

[0004] Lucas et al. (US 2007/0222339 A1) describes an ultrasonic transducer comprising a stack having a plurality of layers, each layer having a top surface and an opposed bottom surface, wherein the plurality of layers of the stack comprises an upper unpoled piezoelectric layer, an underlying lower poled piezoelectric layer, and a dielectric layer. The dielectric layer is connected to the piezoelectric layer and defines an opening extending a second predetermined length in a direction substantially parallel to the axis of the stack. A plurality of first kerf slots are defined therein the stack, each first kerf slot extending a predetermined depth therein the stack through the upper piezoelectric layer and into the lower piezoelectric layer and a first predetermined length in a direction substantially parallel to the axis.

[0005] Dausch et al. (WO 2012/075153 A2) describes an ultrasound device including an ultrasonic transducer device having a plurality of transducer elements forming a transducer array. Each transducer element includes a piezoelectric material disposed between a first electrode and a second electrode. One of the first and second electrodes is a ground electrode and the other of the first and second electrodes is a signal electrode. The ultrasound device further includes a cable assembly having a plurality of connective signal elements and a plurality of connective ground elements extending in substantially parallel relation therealong. Each connective element is configured to form an electrically-conductive engagement with respective ones of the signal electrodes and the ground electrodes of the transducer elements in the transducer array. The connective ground elements are alternatingly disposed with the connective signal elements across the cable assembly, to provide shielding between the connective signal elements.

SUMMARY

[0006] In general, in an aspect, an ultrasonic array has piezoelectric material and a plurality of electrodes. Each electrode is electrically connected to a respective signal wire, and the plurality of signal wires are embedded in a printed circuit board, the board having an angle of greater than about 60 degrees with respect to the array.

[0007] In one aspect, there is provided an ultrasound device in accordance with appended claims 1 - 9. In another aspect, there is provided a method of electrically connecting an ultrasound array to a printed circuit board, in accordance with appended claims 10 - 14. In certain implementations, the configuration described above is included in an endoscope. The angle can be greater than 70 degrees. The angle can be greater than 80 degrees. The angle can be approximately 90 degrees. The printed circuit board can be a flexible circuit.

[0008] In general, in an aspect, a method of manufacture of any of the above includes creating vias in the printed circuit board and cutting the vias transversely to expose conductive material at the edge of the board. In certain implementations, the array is then wire bonded to the conductive material, such that the material acts as a wire bonding pad. Other implementations are possible, such as generally when the array is electrically connected to the conductive material by thin metal film, conductive epoxy, or the like. The cutting can be accomplished by a dicing saw or by similar methods. The cutting can be accomplished by a laser.

[0009] In general, in an aspect, an ultrasonic array has piezoelectric material and a plurality of electrodes. Each electrode is correspondingly electrically connected to one of a plurality of signal wires, the wires having an angle of greater than about 60 degrees with respect to the array. In certain implementations, the angle can be greater than 70 degrees. The angle can be greater than 80 degrees. The angle can be approximately 90 degrees.

[0010] In general, in an aspect, a method of manufacture of approximately perpendicular wire bonds includes creating vias in a flexible circuit and cutting the vias transversely to expose conductive material at the edge of the flexible circuit.

[0011] In general, in an aspect, a method of manufacture of electrical connections between an ultrasonic array and a printed circuit board includes creating vias in the board and cutting the vias transversely to expose the conductive material at the edge of the board.

[0012] These and other features and aspects, and combinations of them, maybe expressed as methods, systems, components, means and steps for performing functions, business methods, program products, and in other ways.

[0013] Other advantages and features will become apparent from the following description and from the claims.

[0014] In one aspect, there is provided an ultrasound device comprising:

a transducer stack comprising a piezoelectric material, said piezoelectric material comprising a top surface, a plurality of side surfaces;

a plurality of electrodes formed on said top surface, said plurality of electrodes defining elements of an ultrasound array, wherein each electrode is in electrical communication with a respective ultrasound array bonding pad; and

a printed circuit board comprising a plurality of signal wires embedded therein, wherein an end portion thereof is provided adjacent to a first side surface of said transducer stack such that an angle between said printed circuit board and the top surface of said piezoelectric material is at least 60 degrees, and wherein an edge thereof is aligned with said top surface;

wherein electrical connections are provided between said ultrasound array bonding pads and electrically conductive material exposed in said edge of said printed circuit board such that each electrode is electrically connected to a respective signal wire.

[0015] In another aspect, there is provided a method of electrically connecting an ultrasound array to a printed circuit board, the printed circuit board comprising a plurality of signal wires embedded therein, the method comprising:

providing a transducer stack comprising a piezoelectric material and a plurality of electrodes, wherein said piezoelectric material comprises a top surface, a plurality of side surfaces, wherein said plurality of electrodes are formed on said top surface such that said plurality of electrodes define elements of said ultrasound array, and wherein each electrode is in electrical communication with a respective ultrasound array bonding pad;

cutting the printed circuit board transversely to form an edge of the printed circuit board exposing conductive material at the edge;

providing the printed circuit board such that an end portion thereof is adjacent to a first side surface of said transducer stack, and such that an angle between said printed circuit board and the top surface of said piezoelectric material is at least 60 degrees, and such that an edge thereof is aligned with said top surface; and

forming electrical connections between the ultrasound array bonding pads and electrically conductive material exposed in said edge of said printed circuit board such that each electrode is electrically connected to a respective signal wire.

DESCRIPTION

[0016]

FIG. 1 shows a partial perspective view of the probe end of a conventional endoscope.

FIG. 2 shows a sectional view of the probe end of an endoscope of the present invention.

FIG. 3 shows a partial perspective view of the probe end of an endoscope of the present invention.

FIG. 4 depicts steps, from top to bottom, in the method of manufacture of the present invention.

FIG. 5 shows a graph of impedance in ohms at 10 MHz vs array element number for the endoscope of the Example.

Parts Legend

[0017]

100 Flex circuit, printed circuit board
102 Transducer stack, backing
104 Wire bonding pads
106 Wire to/from array element
108 Piezoelectric material
110 Electrodes
112 Array, ultrasonic array
120 Cut
122 Discarded half of the board edge
124 Exposed conductive material at the board edge
126 Via
128 Signal wire

[0018] Miniaturized high-frequency, ultrasonic phased array endoscopes have been successfully designed and fabricated. An array with an electrical harness (such as flex or PCB or series of conductors) may be set a defined angle relative to a stack. There may be no bend required. The volumetric footprint can be minimized as well as the number of components.

[0019] The advantages of an endoscope of this invention, as well as methods of manufacture of such endoscopes, can be seen by contrast to a conventional endoscope design in FIG. 1. At the probe end, a surface of piezoelectric material 108 is systematically electroded with electrodes 110, such that it defines an array 112 of individual elements that transmit and receive acoustic signals. Piezoelectric materials such as lead zirconate titanate (PZT) or lead manganese niobate in solid solution with lead titanate (PMNx-PT(1-x)) are often used. To achieve additional separation between elements, in some cases kerfs (cuts made into the piezoelectric material 108) are made using a saw, laser, reactive ion etching or other methods. Each element in the array 112 is electrically connected (generally by way of a wire bonding pad) to a wire 106, which is correspondingly electrically connected on its other end by wire bonding pads 104 on a printed circuit board 100. Signal wires (not shown) embedded in the printed circuit board 100 are electrically connected to each pad 104, and send each signal from each element to the distal end of the probe (this is the end which is mechanically manipulated by a clinician). Often, the printed circuit board is a flexible (flex) circuit, which packages many of signal wires composed of conductive material by sandwiching them between flexible polymer layers. Printed circuit board 100 could also be inflexible, in which the insulating layers may be FR-4 fiberglass.

[0020] Note that in the conventional endoscope design of FIG. 1, a flex circuit 100 is approximately parallel to the surface of the array 112 for a significant distance before bending away from the probe end. The smallest dimension possible for such an endoscope is limited by how much of the flex circuit remains at the probe end. Typically, bonding pads 104 are exposed on both the flex circuit 100 and the array 112, and wires 106 are used to attach array pads and flex circuit pads to each other. In order to prevent damage to the flex circuit 100, the manufacturer specifies a minimum bend radius, often on the order of a few millimeters for a multilayer flex circuit such as those used to carry ultrasound array signals. This minimum bend radius requires that the flex circuit extend laterally from the ultrasound array for several millimeters before bending back, which greatly increases the cross-sectional area of the device. It is possible, in some embodiments, that no other structures are needed for mechanical support. In some embodiments, attachment may also be made to wires carried in another structure; if such structure is attached so that the wires meet the plane of the array surface, then a minimum bend radius may be required to avoid damaging such wires. Since the minimum size of a lumen into which the endoscope can enter is limited by the endoscope's cross-sectional area it is desirable to reduce the cross-sectional area as much as possible.

[0021] We now turn to an embodiment of the endoscope of the present invention; see FIGs. 2 and 3. Rather than have a printed circuit board 100 (such as a flex circuit) wire bonded approximately parallel to the surface of an array 112, instead the flex circuits are wire bonded (or otherwise electrically connected) approximately normal to the array surface. In such an arrangement the flex circuit does not bend, and the cross-sectional probe area need only be large enough to accommodate the array elements, bonding pads, and the thickness of the flex circuit at the probe end. This arrangement can be used in a variety of applications, including endoscopic high-frequency phased array ultrasound systems, non-endoscopic high-frequency ultrasound phased arrays, and both endoscopic and non-endoscopic phased and linear ultrasound arrays. In some embodiments, an endoscope of the present invention comprises a 40 MHz, 64-element phased array transducer packaged into a 2.47 mm by 2.42 mm endoscopic form factor, in which the array is a forward looking kerfless design based on PMN-32%PT with an element-to-element pitch of 38 microns. In some embodiments, the angle of the flex circuit with respect to the array is approximately 90 degrees. In some embodiments, the angle of the flex circuit with respect to the array is between 80 and 90 degrees. In some embodiments, the angle of the flex circuit with respect to the array is between 70 and 90 degrees. In some embodiments, the angle of the flex circuit with respect to the array is between about 60 and 90 degrees. In some embodiments crossing the normal plane, the angle of the flex circuit with respect to the array may exceed 90 degrees.

[0022] Attaching a printed circuit board approximately perpendicular to an array creates a manufacturing challenge because wire bonds between the array and the printed circuit board must connect to the board edge-on. In particular, flex circuitry is built by attaching together laminar layers, thus bonding pads cannot easily be mounted on the edge of a flex circuit. Moreover, because wire bonds are usually made between two parallel surfaces, it is difficult to make connections to bonding pads on the surface of a printed circuit board in this configuration, whether it is flexible or inflexible. The present invention solves these challenges by providing a novel method of manufacture. In some embodiments, this method enables wire bonding of signal wires to array elements; electrical connection is also possible using conductive epoxy or thin film metal deposition.

[0023] In a wire bonding embodiment, the method of manufacture includes the following steps (see FIG. 4). A set of filled partial vias 126 is formed in the printed circuit board 100 (FIG. 4 top). These vias correspond to the position of the embedded signal wires 128, which are composed of conductive material suitable for electrical connections. In some embodiments, this procedure is performed twice such that the vias 126 are arranged in two rows through the depth of the printed circuit board 100, with one row through the top two layers and one through the bottom two layers such that they alternate. The board is then cut across its width with a dicing saw so as to cut the vias 126 in half near the edge of the board (FIG. 4 middle), exposing conductive material 124 corresponding to each signal wire at the site of the cut 120 (FIG. 4 bottom). The remainder 122 is discarded. In methods of manufacture of endoscopes of the present invention, wire bonds are then made between an array 112 and the cut vias 126 in the board, thus allowing a connection to be made without introducing any bending in the printed circuit board.

[0024] See below for an example of endoscopes of the present invention constructed using a method of manufacture of the present invention.

Example

[0025] The array substrate was a 2.4mm by 2.4 mm piece of PMN-32%PT lapped to 47 um thickness. An array of 64 electrodes was photolithographically defined on the top surface of this substrate with an electrode width of 27 um and an element-to-element pitch of 37 um. Each electrode was fanned out to a bonding pad arranged in two rows on each side of the array (four rows total). A 1.2 um layer of aluminum was sputtered onto the back side of the array to define a ground electrode, and a thick layer of conductive epoxy was attached to it to act as an absorbent acoustic backing layer. This epoxy was removed with a dicing saw in order to avoid making the bonding pads piezoelectrically active. Two 6-layer flex circuit boards were designed to connect to the elements from either side of the array. Each flex circuit had 32 traces terminating at individual copper-filled vias near the end of the board. The flex circuits were cut through the middle of the solid vias using a dicing saw. The two flex circuit boards were epoxied onto opposite sides of the transducer stack such that the diced vias were aligned with the bonding pads fanned out from the array. A jig was then machined to hold the flex + transducer stack upright in front of the wire-bonding tool. 15-micron thick aluminum wire bonds were used to connect the bonding pads on the array to the diced vias within the thickness of the array. The wirebonds were encapsulated with a thick insulating epoxy consisting of a 30% by volume mixture of Alumina powder and Epotek 301 (Epotek) insulating epoxy. A matching layer/lens combination was then epoxied onto the front face of the endoscope. Micro-coaxial cables were directly soldered to the flex circuit at the distal end of the probe.

[0026] Measurements of the impedance of the elements (see FIG. 5) measured from the distal end of the flex circuit show that this technique does indeed provide a good electrical connection to the transducer elements, with low impedance electrical connections in the wire bond between the flex circuit and the array.

Claims

1. An ultrasonic device comprising:

   a transducer stack (102) comprising a piezoelectric material (108), said piezoelectric material (108) comprising a top surface, a plurality of side surfaces;
   a plurality of electrodes (110) and a plurality of ultrasound array bonding pads formed on said top surface, said plurality of electrodes (110) defining elements of an ultrasound array (112), wherein each electrode (110) is in electrical communication with a respective ultrasound array bonding pad (104); and
   characterized in that
   said ultrasonic device further comprises a printed circuit board (100) comprising a plurality of signal wires (128) embedded therein, wherein said printed circuit board comprises a lateral surface and a plurality of side edges, wherein an end portion of the printed circuit board is provided adjacent to a first side surface of said transducer stack (102) such that an angle between said lateral surface of said printed circuit board (100) and the top surface of said piezoelectric material (108) is at least 60 degrees and wherein an side edge of said printed circuit board is aligned with said top surface;
   wherein the ultrasonic device further comprises electrical connections provided between said ultrasound array bonding pads (104) and electrically conductive material (124) exposed in said edge of said printed circuit board (100) such that each electrode (110) is electrically connected to a respective signal wire (128).

2. The ultrasound device according to claim 1 wherein said printed circuit board (100) comprises:

   a set of vias (126) formed at an end of said printed circuit board (100), such that the vias (126) intersect respective signal wires (128) within said printed circuit board (100), said vias (126) extend at least partially through said printed circuit board (100);
   wherein said vias (126) are filled with the electrically conductive material (124); and
   wherein said vias (126) are exposed in said edge of said printed circuit board (100), forming a plurality of bonding pads (104) in said edge.

3. The ultrasound device according to claim 2 wherein said end portion of said printed circuit board (100) is parallel to said first side surface of said transducer stack (102).

4. The ultrasound device according to claim 2 or 3

wherein said printed circuit board (100) is positioned relative to said transducer stack (102) such that said edge of said printed circuit board (100) is approximately coplanar with said ultrasound array bonding pads (104).

5. The ultrasound device according to any one of claims 2 to 4 wherein said printed circuit board (100) is adhered to said first side surface of said transducer stack (102).

6. The apparatus of any of claims 2 to 5 wherein said printed circuit board (100) is flexible.

7. The ultrasound device according to claim 2 wherein said printed circuit board (100) is a first printed circuit board, said plurality of electrodes (110) are a plurality of first electrodes, said plurality of signal wires (128) are a plurality of first signal wires, said plurality of bonding pads are a plurality of first bonding pads, said ultrasound device further comprising a plurality of second electrodes spatially interleaved with said plurality of first electrodes, said plurality of second electrodes defining additional elements of said ultrasound array (112), said ultrasound array bonding pads (104) comprise first ultrasound array bonding pads and second ultrasound array bonding pads, said ultrasound device further comprising a second printed circuit board;

said second printed circuit board comprising a plurality of second signal wires embedded therein, wherein an edge of said second printed circuit board comprises a plurality of second bonding pads, each second bonding pad being in electrical communication with a respective second signal wire;
wherein an end portion of said second printed circuit board is provided adjacent to a second side surface of said transducer stack (102), wherein an angle between said end portion of said second printed circuit board and said top surface is at least 60 degrees;
wherein electrical connections are provided between said second bonding pads of said second printed circuit boards and said second ultrasound array bonding pads such that each second electrode is electrically connected to a respective second signal wire; and
wherein said first printed circuit board and said second printed circuit boards are provided on opposite sides of said transducer stack (102).

8. The ultrasound device according to any one of claims 2 to 7, wherein the electrical connections are formed by wire bonding.

9. An ultrasound probe comprising an ultrasound device according to any one of claims 2 to 8.

10. A method of electrically connecting an ultrasound array (112) to a printed circuit board (100), the printed circuit board (100) comprising a plurality of signal wires (128) embedded therein, the method comprising:

providing a transducer stack (102) comprising a piezoelectric material (108) and a plurality of electrodes (110), wherein said piezoelectric material (108) comprises a top surface, a plurality of side surfaces, wherein said plurality of electrodes (110) are formed on said top surface such that said plurality of electrodes (110) define elements of said ultrasound array (112), and wherein each electrode (110) is in electrical communication with a respective ultrasound array bonding pad (104);
cutting the printed circuit board (100) transversely to form an edge on the side of the lateral surface of the printed circuit board (100) exposing conductive material (124) at the edge;
providing the printed circuit board (100) such that an end portion thereof is adjacent to a first side surface of said transducer stack (102), and such that an angle between said lateral surface of said printed circuit board (100) and the top surface of said piezoelectric material (108) is at least 60 degrees, and such that an edge of said printed circuit board is aligned with said top surface; and
forming electrical connections between the ultrasound array bonding pads (104) and electrically conductive material (124) exposed in said edge of said printed circuit board (100) such that each electrode (110) is electrically connected to a respective signal wire (128).

11. The method according to claim 10 wherein the following steps are performed prior to cutting the printed circuit board (100):

forming a set of vias (126) within the printed circuit board (100), such that the vias (126) intersect respective signal wires (128) that are embedded within the printed circuit board (100);
filling the vias (126) with an electrically conductive material (124), thereby forming a set of filled vias (126) within the printed circuit board (100); and
wherein the printed circuit board (100) is cut transversely through the set of filled vias (126) to form an edge of the printed circuit board (100), such that the set of filled vias (126) are cut to form a plurality of bonding pads and to expose the plurality of bonding pads at the edge, wherein the bonding pads are in electrical communi-

cation with respective signal wires (128) within the printed circuit board (100); and
wherein the electrical connections are formed between the ultrasound array bonding pads and the bonding pads such that each electrode (110) is electrically connected to a respective signal wire (128).

12. The method according to claim 10 or 11 wherein the electrical connection are formed by wire bonding.

13. The method according to claim 10 or 11 wherein the electrical connections are formed by thin metal film or conductive epoxy.

14. The method according to claim 11 wherein the vias (126) are arranged in two rows through the depth of the printed circuit board (100), wherein one row of vias (126) extends through two top layers of the printed circuit board (100), and the other row of vias (126) extends through two bottom layers of the printed circuit board (100), and wherein the vias (126) in the two rows are formed such that they alternate.

Patentansprüche

1. Ultraschallvorrichtung, umfassend:

einen Wandlerstapel (102), umfassend ein piezoelektrisches Material (108), wobei das piezoelektrische Material (108) eine obere Oberfläche, eine Vielzahl von Seitenflächen umfasst;
eine Vielzahl von Elektroden (110) und eine Vielzahl von auf der oberen Oberfläche gebildeten Ultraschall-Array-Anschlussflächen, wobei die Vielzahl von Elektroden (110) Elemente eines Ultraschall-Arrays (112) definiert, wobei jede Elektrode (110) in elektrischer Verbindung mit einer jeweiligen Ultraschall-Array-Anschlussfläche (104) steht; und
dadurch gekennzeichnet, dass
die Ultraschallvorrichtung weiter eine Leiterplatte (100) umfasst, die eine Vielzahl von darin eingebetteten Signalleitungen (128) umfasst, wobei die Leiterplatte eine seitliche Oberfläche und eine Vielzahl von Seitenkanten umfasst, wobei ein Endabschnitt der Leiterplatte so benachbart zu einer ersten Seitenfläche des Wandlerstapels (102) angebracht ist, dass ein Winkel zwischen der seitlichen Oberfläche der Leiterplatte (100) und der oberen Oberfläche des piezoelektrischen Materials (108) mindestens 60 Grad beträgt, und wobei eine Seitenkante der Leiterplatte mit der oberen Oberfläche ausgerichtet ist;
wobei die Ultraschallvorrichtung weiter elektrische Verbindungen umfasst, die so zwischen den Ultraschall-Array-Anschlussflächen (104) und in der Kante der Leiterplatte (100) freiliegendem elektrisch leitenden Material (124) angebracht sind, dass jede Elektrode (110) elektrisch mit einer jeweiligen Signalleitung (128) verbunden ist.

2. Ultraschallvorrichtung nach Anspruch 1, wobei die Leiterplatte (100) umfasst:

einen Satz von Durchkontaktierungen (126), die an einem Ende der Leiterplatte (100) gebildet sind, sodass die Durchkontaktierungen (126) jeweilige Signalleitungen (128) innerhalb der Leiterplatte (100) kreuzen, wobei die Durchkontaktierungen (126) sich mindestens teilweise durch die Leiterplatte (100) hindurch erstrecken;
wobei die Durchkontaktierungen (126) mit dem elektrisch leitenden Material (124) gefüllt sind; und
wobei die Durchkontaktierungen (126) in der Kante der Leiterplatte (100) freigelegt sind, wobei sie eine Vielzahl von Anschlussflächen (104) in der Kante bilden.

3. Ultraschallvorrichtung nach Anspruch 2, wobei der Endabschnitt der Leiterplatte (100) parallel zu der ersten Seitenfläche des Wandlerstapels (102) ist.

4. Ultraschallvorrichtung nach Anspruch 2 oder 3, wobei die Leiterplatte (100) bezüglich des Wandlerstapels (102) so positioniert ist, dass die Kante der Leiterplatte (100) annähernd koplanar mit den Ultraschall-Array-Anschlussflächen (104) ist.

5. Ultraschallvorrichtung nach einem der Ansprüche 2 bis 4, wobei die Leiterplatte (100) an die erste Seitenfläche des Wandlerstapels (102) angeheftet ist.

6. Vorrichtung nach einem der Ansprüche 2 bis 5, wobei die Leiterplatte (100) flexibel ist.

7. Ultraschallvorrichtung nach Anspruch 2, wobei die Leiterplatte (100) eine erste Leiterplatte ist, die Vielzahl von Elektroden (110) eine Vielzahl von ersten Elektroden ist, die Vielzahl von Signalleitungen (128) eine Vielzahl von ersten Signalleitungen ist, die Vielzahl von Anschlussflächen eine Vielzahl von ersten Anschlussflächen ist, wobei die Ultraschallvorrichtung weiter eine Vielzahl von zweiten Elektroden umfasst, die mit der Vielzahl von ersten Elektroden räumlich verschachtelt sind, wobei die Vielzahl von zweiten Elektroden zusätzliche Elemente des Ultraschall-Arrays (112) definiert, wobei die Ultraschall-Array-Anschlussflächen (104) erste Ultraschall-Array-Anschlussflächen und zweite Ultraschall-Array-Anschlussflächen umfassen, wobei die Ultraschallvorrichtung weiter eine zweite Leiterplatte umfasst; wobei die zweite Leiterplatte eine Vielzahl von darin

eingebetteten zweiten Signalleitungen umfasst, wobei eine Kante der zweiten Leiterplatte eine Vielzahl von zweiten Anschlussflächen umfasst, wobei jede zweite Anschlussfläche in elektrischer Verbindung mit einer jeweiligen zweiten Signalleitung steht;
wobei ein Endabschnitt der zweiten Leiterplatte benachbart zu einer zweiten Seitenfläche des Wandlerstapels (102) angebracht ist, wobei ein Winkel zwischen dem Endabschnitt der zweiten Leiterplatte und der oberen Oberfläche mindestens 60 Grad beträgt;
wobei elektrische Verbindungen so zwischen den zweiten Anschlussflächen der zweiten Leiterplatten und den zweiten Ultraschall-Array-Anschlussflächen angebracht sind, dass jede zweite Elektrode elektrisch mit einer jeweiligen zweiten Signalleitung verbunden ist; und
wobei die erste Leiterplatte und die zweiten Leiterplatten an entgegengesetzten Seiten des Wandlerstapels (102) angebracht sind.

8. Ultraschallvorrichtung nach einem der Ansprüche 2 bis 7, wobei die elektrischen Verbindungen durch Drahtbonden gebildet sind.

9. Ultraschallsonde, umfassend eine Ultraschallvorrichtung nach einem der Ansprüche 2 bis 8.

10. Verfahren zum elektrischen Verbinden eines Ultraschall-Arrays (112) mit einer Leiterplatte (100), wobei die Leiterplatte (100) eine Vielzahl von darin eingebetteten Signalleitungen (128) umfasst, wobei das Verfahren umfasst:

Bereitstellen eines Wandlerstapels (102), umfassend ein piezoelektrisches Material (108) und eine Vielzahl von Elektroden (110), wobei das piezoelektrische Material (108) eine obere Oberfläche, eine Vielzahl von Seitenflächen, umfasst, wobei die Vielzahl von Elektroden (110) so auf der oberen Oberfläche gebildet ist, dass die Vielzahl von Elektroden (110) Elemente des Ultraschall-Arrays (112) definiert, und wobei jede Elektrode (110) in elektrischer Verbindung mit einer jeweiligen Ultraschall-Array-Anschlussfläche (104) steht;
Durchschneiden der Leiterplatte (100) in Querrichtung, um eine Kante an der Seite der seitlichen Oberfläche der Leiterplatte (100) zu bilden, wodurch leitendes Material (124) an der Kante freigelegt wird;
so Anbringen der Leiterplatte (100), dass ein Endabschnitt davon sich benachbart zu einer ersten Seitenfläche des Wandlerstapels (102) befindet, und so, dass ein Winkel zwischen der seitlichen Oberfläche der Leiterplatte (100) und der oberen Oberfläche des piezoelektrischen Materials (108) mindestens 60 Grad beträgt, und so, dass eine Kante der Leiterplatte mit der oberen Oberfläche ausgerichtet ist; und
Bilden von elektrischen Verbindungen zwischen den Ultraschall-Array-Anschlussflächen (104) und in der Kante der Leiterplatte (100) freigelegtem elektrisch leitendem Material (124), sodass jede Elektrode (100) elektrisch mit einer jeweiligen Signalleitung (128) verbunden ist.

11. Verfahren nach Anspruch 10, wobei die folgenden Schritte vor dem Durchschneiden der Leiterplatte (100) ausgeführt werden:

Bilden eines Satzes von Durchkontaktierungen (126) innerhalb der Leiterplatte (100), sodass die Durchkontaktierungen (126) jeweilige Signalleitungen (128), die innerhalb der Leiterplatte (100) eingebettet sind, kreuzen;
Füllen der Durchkontaktierungen (126) mit einem elektrisch leitenden Material (124), dadurch Bilden eines Satzes gefüllter Durchkontaktierungen (126) innerhalb der Leiterplatte (100); und
wobei die Leiterplatte (100) in Querrichtung durch den Satz gefüllter Durchkontaktierungen (126) hindurch durchgeschnitten wird, um eine Kante der Leiterplatte (100) zu bilden, sodass der Satz gefüllter Durchkontaktierungen (126) durchschnitten wird, um eine Vielzahl von Anschlussflächen zu bilden und um die Vielzahl von Anschlussflächen an der Kante freizulegen, wobei die Anschlussflächen in elektrischer Verbindung mit jeweiligen Signalleitungen (128) innerhalb der Leiterplatte (100) stehen; und
wobei die elektrischen Verbindungen so zwischen den Ultraschall-Array-Anschlussflächen und den Anschlussflächen gebildet werden, dass jede Elektroden (110) elektrisch mit einem jeweiligen Signaldraht (128) verbunden ist.

12. Verfahren nach Anspruch 10 oder 11, wobei die elektrischen Verbindungen durch Drahtbonden gebildet werden.

13. Verfahren nach Anspruch 10 oder 11, wobei die elektrischen Verbindungen durch eine dünne Metallschicht oder leitendes Epoxy gebildet werden.

14. Verfahren nach Anspruch 11, wobei die Durchkontaktierungen (126) in zwei Reihen durch die Tiefe der Leiterplatte (100) hindurch angeordnet sind, wobei eine Reihe von Durchkontaktierungen (126) sich durch zwei obere Schichten der Leiterplatte (100) erstreckt und die andere Reihe von Durchkontaktierungen (126) sich durch zwei untere Schichten der Leiterplatte (100) erstreckt, und wobei die Durchkontaktierungen (126) in den zwei Reihen so gebildet sind, dass sie sich abwechseln.

Revendications

1. Dispositif à ultrasons comprenant :

   un empilement de transducteurs (102) comprenant un matériau piézo-électrique (108), ledit matériau piézo-électrique (108) comprenant une surface supérieure, un certain nombre de surfaces latérales ;
   un certain nombre d'électrodes (110) et un certain nombre de plots de connexion de réseau à ultrasons formés sur ladite surface supérieure, lesdites plusieurs électrodes (110) définissant des éléments d'un réseau à ultrasons (112) ;
   dans lequel chaque électrode (110) est mise en communication électrique avec un plot de connexion respectif de réseau à ultrasons (104) ; et
   caractérisé en ce que
   ledit dispositif à ultrasons comprend en outre une carte de circuits imprimés (100) dans laquelle sont encastrés plusieurs fils de transmission de signaux (128) ; dans lequel ladite carte de circuits imprimés comprend une surface latérale et un certain nombre de bords latéraux ;
   dans lequel une portion terminale de la carte de circuits imprimés est prévue en position adjacente à une première surface latérale dudit empilement de transducteurs (102) d'une manière telle que l'on forme un angle entre ladite surface latérale de ladite carte de circuits imprimés (100) et la surface supérieure dudit matériau piézo-électrique (108) s'élevant à au moins 60° ; et
   dans lequel un bord latéral de ladite carte de circuits imprimés est mis en alignement avec la surface supérieure ;
   dans lequel le dispositif à ultrasons comprend en outre des connexions électriques prévues entre lesdits plots de connexion de réseau à ultrasons (104) et un matériau électroconducteur (124) exposé dans ledit bord de ladite carte de circuits imprimés (100) d'une manière telle que chaque électrode (110) est connectée par voie électrique à un fil respectif de transmission de signaux (128).

2. Dispositif à ultrasons selon la revendication 1, dans lequel ladite carte de circuits imprimés (100) comprend :

   un jeu de trous d'interconnexion (126) formés à une extrémité de ladite carte de circuits imprimés (100), d'une manière telle que les trous d'interconnexion (126) coupent des fils respectifs de transmission de signaux (128) au sein de ladite carte de circuits imprimés (100), lesdits trous d'interconnexion (126) s'étendant au moins en partie à travers ladite cartes de circuits imprimés (100) ;
   dans lequel lesdits trous d'interconnexion (126) sont remplis avec le matériau électroconducteur (124) ; et
   dans lequel lesdits trous d'interconnexion (120) sont exposés dans ledit bord de ladite carte de circuits imprimés (100) pour former un certain nombre de plots de connexion (104) dans ledit bord.

3. Dispositif à ultrasons selon la revendication 2, dans lequel ladite portion terminale de ladite carte de circuits imprimés (100) est parallèle à ladite surface latérale dudit empilement de transducteurs (102).

4. Dispositif à ultrasons selon la revendication 2 ou 3, dans lequel ladite carte de circuits imprimés (100) est disposée par rapport audit empilement de transducteurs (102) d'une manière telle que ledit bord de ladite carte de circuits imprimés (100) est approximativement coplanaire avec lesdits plots de connexion de réseau à ultrasons (104).

5. Dispositif à ultrasons selon l'une quelconque des revendications 2 à 4, dans lequel ladite carte de circuits imprimés (100) adhère à ladite première surface latérale dudit empilement de transducteurs (102).

6. Dispositif à ultrasons selon l'une quelconque des revendications 2 à 5, dans lequel ladite carte de circuits imprimés (100) est flexible.

7. Dispositif à ultrasons selon la revendication 2, dans lequel ladite carte de circuits imprimés (100) représente une première carte de circuits imprimés ; lesdites plusieurs électrodes (110) représentent un certain nombre de premières électrodes ; lesdites plusieurs fils de transmission de signaux (128) représentent un certain nombre de premiers fils de transmission de signaux ; lesdites plusieurs plots de connexions représentent un certain nombre de premiers plots de connexion ; ledit dispositif à ultrasons comprend en outre un certain nombre de deuxièmes électrodes disposées en entrelacement spatial avec lesdites plusieurs premières électrodes ; lesdites plusieurs deuxièmes électrodes définissent des éléments supplémentaires dudit réseau à ultrasons (112) ; lesdits plots de connexion de réseau à ultrasons (104) comprennent des premiers plots de connexion de réseau à ultrasons et des deuxièmes plots de connexion de réseau à ultrasons ; ledit dispositif à ultrasons comprend en outre une deuxième carte de circuits imprimés ;
   un certain nombre de deuxièmes fils de transmission de signaux sont encastrés dans ladite deuxième carte de circuits imprimés ; dans lequel un bord de ladite carte de circuits imprimés comprend un certain nombre de deuxièmes plots de connexion, chaque deuxième plot de connexion étant mis en communi-

cation électrique avec un deuxième fil respectif de transmission de signaux ;
dans lequel une portion terminale de ladite deuxième carte de circuits imprimés est prévue en position adjacente à une deuxième surface latérale dudit empilement de transducteurs (102) ; dans lequel on obtient un angle entre ladite portion terminale de ladite deuxième carte de circuit imprimé et ladite surface supérieure s'élevant à au moins 60° ;
dans lequel on prévoit des connexions électriques entre lesdits deuxièmes plots de connexion desdites deuxièmes cartes de circuits imprimés et lesdits deuxièmes plots de connexion de réseau à ultrasons d'une manière telle que chaque deuxième électrode est reliée par voie électrique à un deuxième fil respectif de transmission de signaux ; et
dans lequel ladite première carte de circuits imprimés et lesdites deuxièmes cartes de circuits imprimés sont prévues sur des côtés opposés dudit empilement de transducteurs (102).

8. Dispositif à ultrasons selon l'une quelconque des revendications 2 à 7, dans lequel les connexions électriques sont réalisées via une soudure de fils.

9. Sonde à ultrasons comprenant un dispositif à ultrasons selon l'une quelconque des revendications 2 à 8.

10. Procédé pour la connexion électrique d'un réseau à ultrasons (112) à une carte de circuits imprimés (100), un certain nombre de fils de transmission de signaux (128) étant encastrés dans la carte de circuits imprimés (100), le procédé comprenant le fait de :

procurer un empilement de transducteurs (102) comprenant un matériau piézo-électrique (108) et un certain nombre d'électrodes (110) ; dans lequel ledit matériau piézo-électrique (108) comprend une surface supérieure, un certain nombre de surfaces latérales ; dans lequel lesdites plusieurs électrodes (110) sont formées sur ladite surface supérieure d'une manière telle que lesdites plusieurs électrodes (110) définissent des éléments dudit réseau à ultrasons (112) ; et dans lequel chaque électrode (110) est mise en communication électrique avec un plot de connexion respectif de réseau à ultrasons (104) ;
découper la carte de circuits imprimés (100) en direction transversale pour former un bord sur le côté de la surface latérale de la carte de circuits imprimés (100) en exposant un matériau conducteur (124) au bord ;
procurer la carte de circuits imprimés (100) d'une manière telle qu'une portion terminale de cette dernière est mise en position adjacente à une première surface latérale dudit empilement de transducteurs (102) et d'une manière telle que l'on obtient un angle entre ladite surface latérale de ladite carte de circuits imprimés (100) et la surface supérieure dudit matériau piézoélectrique (108) s'élevant à au moins 60°, et d'une manière telle qu'un bord de ladite carte de circuits imprimés est mis en alignement avec ladite surface supérieure ; et
former des connexions électriques entre les plots de connexion de réseau à ultrasons (104) et un matériau électroconducteur (124) exposé audit bord de ladite carte de circuits imprimés (100), d'une manière telle que chaque électrode (110) est reliée par voie électrique à un fil respectif de transmission de signaux (128).

11. Procédé selon la revendication 10, dans lequel les étapes suivantes sont mises en oeuvre avant la découpe de la carte de circuits imprimés (100) :

la formation d'un jeu de trous d'interconnexion (126) au sein de la carte de circuits imprimés (100), d'une manière telle que les trous d'interconnexion (126) coupent des fils respectifs de transmission de signaux (128) qui sont encastrés au sein de la carte de circuits imprimés (100) ;
le remplissage des trous d'interconnexion (126) avec un matériau électroconducteur (124) pour ainsi obtenir un jeu de trous d'interconnexion remplis (126) au sein de la carte de circuits imprimés (100) ; et
dans lequel la carte de circuits imprimés (100) est découpée en direction transversale à travers le jeu de trous d'interconnexion remplis (126) pour former un bord de la carte de circuits imprimés (100), d'une manière telle que le jeu de trous d'interconnexion remplis (126) sont coupés pour former un certain nombre de plots de connexion et pour exposer lesdits plusieurs plots de connexion au bord ; dans lequel les plots de connexion sont mis en communication électrique avec des fils respectifs de transmission de signaux (128) au sein de la carte de circuits imprimés (100) ; et
dans lequel les connexions électriques sont réalisées entre les plots de connexion de réseau à ultrasons et les plots de connexion d'une manière telle que chaque électrode (110) est reliée par voie électrique à un fil respectif de transmission de signaux (128).

12. Procédé selon la revendication 10 ou 11, dans lequel les connexions électriques sont réalisées via une soudure de fils.

13. Procédé selon la revendication 10 ou 11, dans lequel les connexions électriques sont réalisées via un mince film métallique ou une résine époxy conductrice.

14. Procédé selon la revendication 11, dans lequel les trous d'interconnexion (126) sont disposés en deux rangées sur la profondeur de la carte de circuits imprimés (100) ; dans lequel une rangée de trous d'interconnexion (126) s'étend à travers deux couches supérieures de la carte de circuits imprimés, et l'autre rangée de trous d'interconnexion (126) s'étend à travers deux couches inférieures de la carte de circuits imprimés (100) ; et dans lequel les trous d'interconnexion (126) dans les deux rangées sont réalisés d'une manière telle qu'ils alternent.

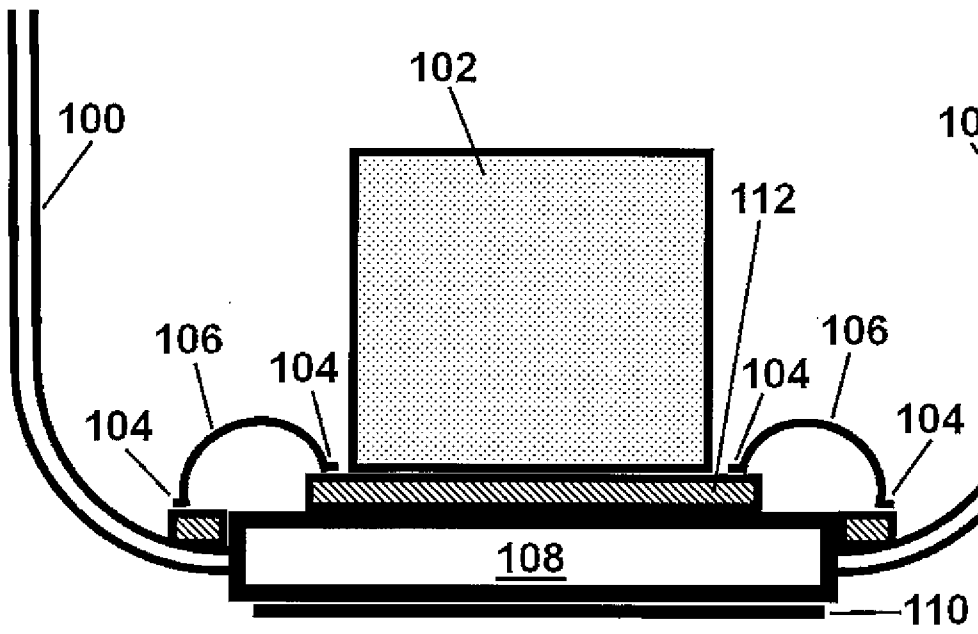

FIG. 1

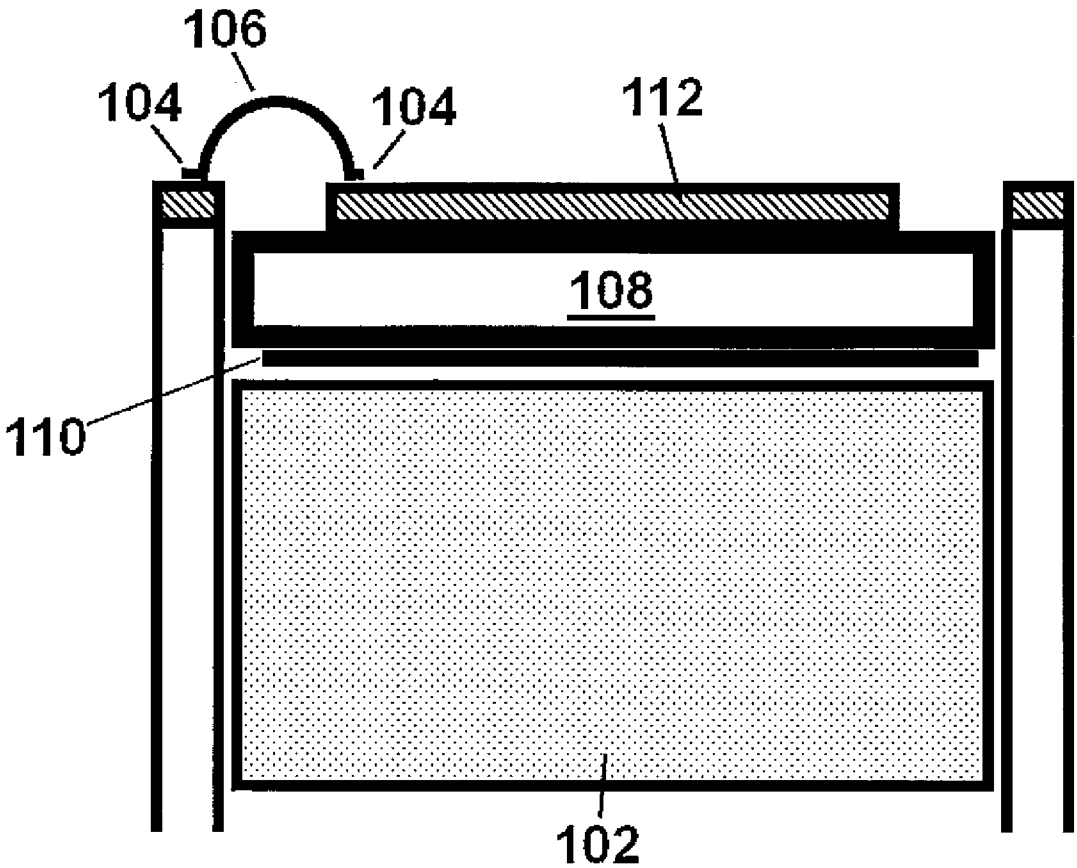

FIG. 2

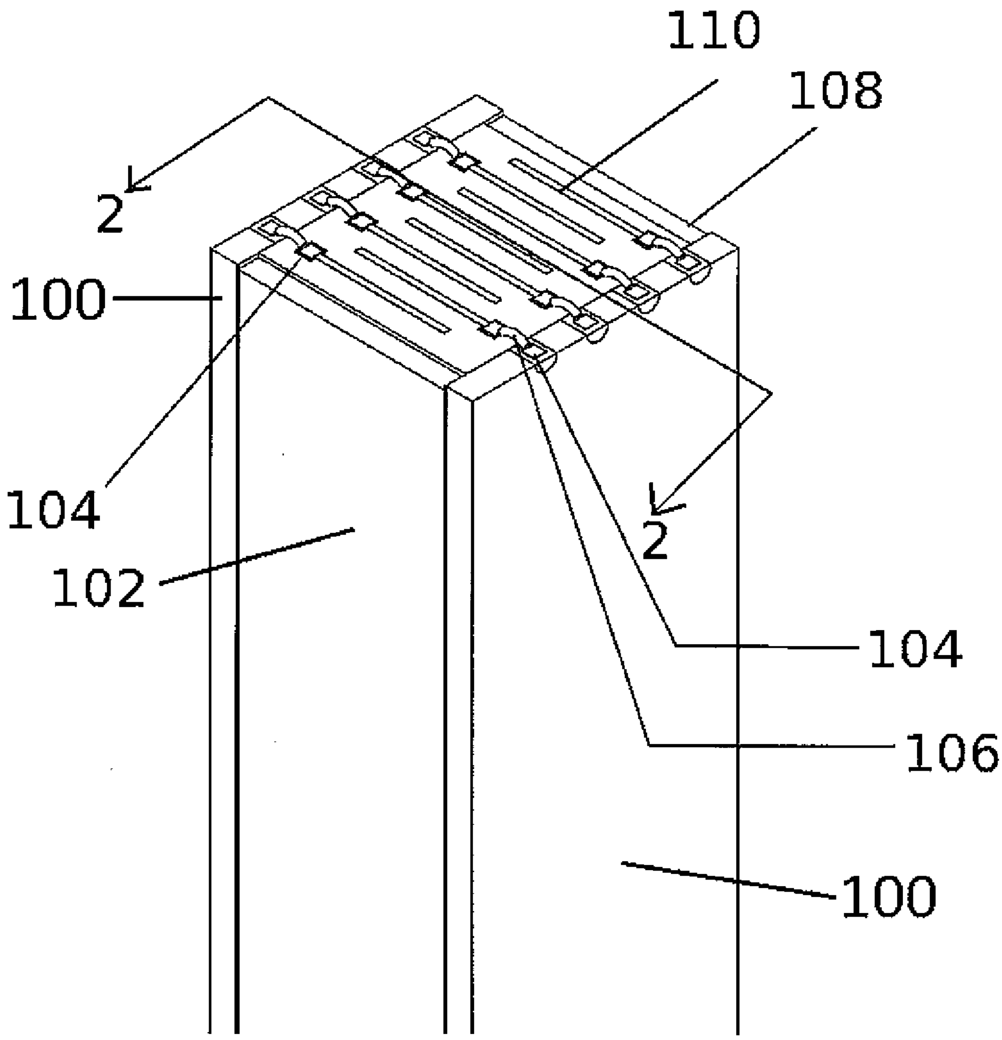

FIG. 3

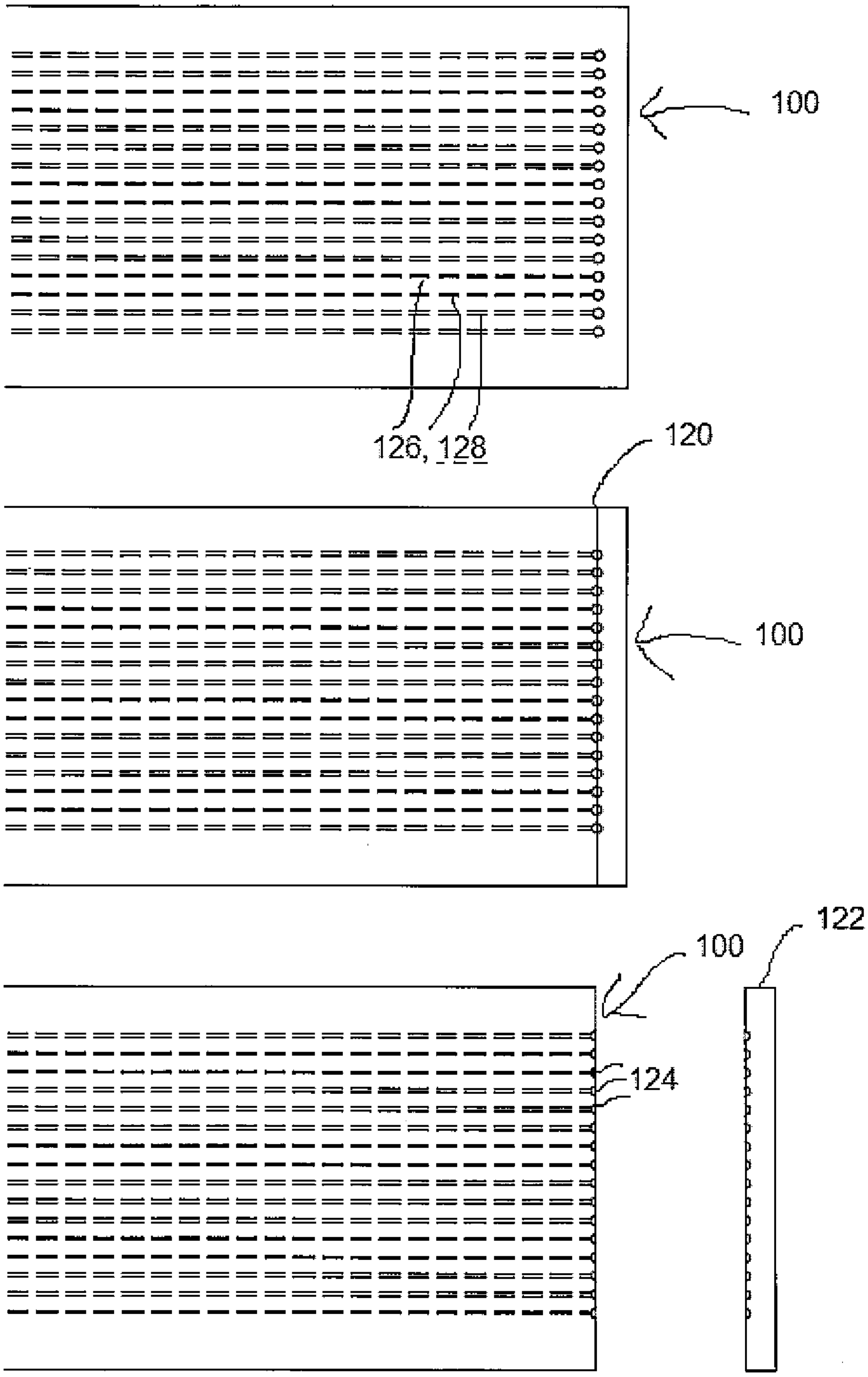

FIG. 4

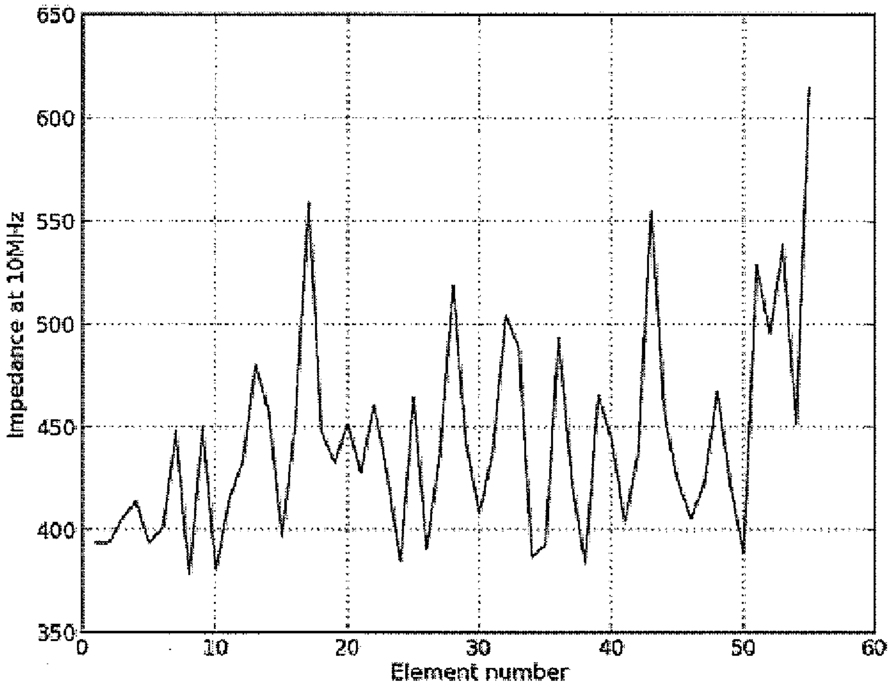
650
600
550
500
450
400
350
0
10
20
30
40
50
60
Impedance at 10MHz
Element number

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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- WO 2012075153 A2, Dausch **[0005]**

patsnap

专利名称(译)	超声内窥镜及其制造方法		
公开(公告)号	EP2883429A1	公开(公告)日	2015-06-17
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当前申请(专利权)人(译)	达尔豪斯大学		
[标]发明人	BEZANSON ANDRE B ADAMSON ROBERT B A BROWN JEREMY A		
发明人	BEZANSON, ANDRE B. ADAMSON, ROBERT B.A. BROWN, JEREMY A.		
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CPC分类号	A61B8/12 A61B8/4488 H05K1/189 H05K3/0052 H05K3/403 H05K2203/049 Y10T29/49151 Y10T29/49165		
优先权	61/710696 2012-10-06 US 61/681320 2012-08-09 US		
其他公开文献	EP2883429B1 EP2883429A4		
外部链接	Espacenet		

摘要(译)

为了解决常规换能器的局限性，为相控阵换能器提供适合于包装到例如内窥镜中的形状系数。 还提供了一种小型封装换能器的制造方法，由此通过以近似垂直于阵列表面的角度将信号线电连接到阵列电极上来减小整体封装尺寸，从而大大消除了传统印刷电路板的弯曲半径要求。 柔性电路。