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(56) References cited:

WO-A1-2007/099746	**WO-A2-2004/021404**
JP-A- 6 047 045	**US-A- 4 651 310**
US-A- 5 381 385	**US-A- 5 792 058**
US-A1- 2004 193 051	**US-A1- 2007 038 111**

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Description

TECHNICAL FIELD

[0001] The present invention is directed to the area of transducers for ultrasound imaging systems, devices and systems containing the transducers, and methods of making and using the transducers. The present invention is also directed to transducers for an intravascular ultrasound imaging system.

BACKGROUND

[0002] Intravascular ultrasound ("IVUS") imaging systems have proven diagnostic capabilities for a variety of diseases and disorders. For example, IVUS imaging systems have been used as an imaging modality for diagnosing blocked blood vessels and providing information to aid medical practitioners in selecting and placing stents and other devices to restore or increase blood flow. IVUS imaging systems have been used to diagnose atheromatous plaque build-up at particular locations within blood vessels. IVUS imaging systems can be used to determine the existence of an intravascular obstruction or stenosis, as well as the nature and degree of the obstruction or stenosis. IVUS imaging systems can be used to visualize segments of a vascular system that may be difficult to visualize using other intravascular imaging techniques, such as angiography, due to, for example, movement (*e.g.*, a beating heart) or obstruction by one or more structures (*e.g.*, one or more blood vessels not desired to be imaged). IVUS imaging systems can be used to monitor or assess ongoing intravascular treatments, such as angiography and stent placement in real (or almost real) time. Moreover, IVUS imaging systems can be used to monitor one or more heart chambers.

[0003] IVUS imaging systems have been developed to provide a diagnostic tool for visualizing a variety is diseases or disorders. An IVUS imaging system can include a control module (with a pulse generator, an image processor, and a monitor), a catheter, and one or more transducers disposed in the catheter. The transducer-containing catheter can be positioned in a lumen or cavity within, or in proximity to, a region to be imaged, such as a blood vessel wall or patient tissue in proximity to a blood vessel wall. The pulse generator in the control module generates electrical pulses that are delivered to the one or more transducers and transformed to acoustic pulses that are transmitted through patient tissue. Reflected pulses of the transmitted acoustic pulses are absorbed by the one or more transducers and transformed to electric pulses. The transformed electric pulses are delivered to the image processor and converted to an image displayable on the monitor.

[0004] JP H06-47045 discloses a piezoelectric transducer having an insulating member having heat resistance above the melting point of solder, which is disposed on the outer periphery of a back load member. The surface electrodes and lead wires are connected to the surface of this insulating member.

[0005] Furthermore, US 4,651,310 discloses a structure wherein contacts are soldered to a heat-resistant polymeric film which extends out of the piezoelectric material, such that in soldering work where the portions of the electrodes and the lead wires to be soldered are subjected temporarily to high temperature heating, deformation of the electrodes for driving can be inhibited.

BRIEF SUMMARY

[0006] The present invention provides an ultrasound transducer according to claim 1, in which a non-transducing pad is configured and arranged to provide protection from heat to the transducer's piezoelectric material as a wire is attached using heat-based bonding techniques.

[0007] Further advantageous embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Non-limiting and non-exhaustive embodiments of the present invention are described with reference to the following drawings. In the drawings, like reference numerals refer to like parts throughout the various figures unless otherwise specified.

[0009] For a better understanding of the present invention, reference will be made to the following Detailed Description, which is to be read in association with the accompanying drawings, wherein:

FIG. 1 is a schematic view of one embodiment of an intravascular ultrasound imaging system, according to the invention;

FIG. 2 is a schematic side view of one embodiment of a catheter of an intravascular ultrasound imaging system, according to the invention;

FIG. 3 is a schematic perspective view of one embodiment of a distal end of an elongated member of the catheter shown in FIG. 2 with an imaging core disposed in a lumen in the distal end of the elongated member, according to the invention;

FIG. 4 is schematic side view of one embodiment of a tip of a catheter with a transducer and a twisted pair cable, according to the invention;

FIG. 5 is a schematic side view of one embodiment of a tip of a catheter with a modular arrangement for attachment of a transducer, according to the invention;

FIG. 6 is a schematic perspective view of one embodiment of a transducer element with non-transducing pads, according to the invention;

FIG. 7 is a schematic perspective view of one embodiment of a transducer with the transducer element of FIG. 6, according to the invention;

FIG. 8 is a schematic top view of one embodiment of an arrangement containing multiple transducers of FIG. 7, according to the invention;

FIG. 9 is a schematic top view of another embodiment of an arrangement containing multiple transducers, according to the invention;

FIG. 10 is a schematic perspective view of one embodiment of a transducer of FIG. 9 with the transducer element of FIG. 6, according to the invention;

FIGs. 11A and 11B are schematic front and back side views of a further embodiment of a transducer, according to the invention;

FIGs 11C, 11D, and 11E are schematic top views of first, second, and third metal layers of the transducer of FIGs. 11A and 11B, also illustrating the arrangement of multiple transducers (separated by the dotted lines), according to the invention;

FIG. 12 is a schematic cross-sectional view of a fourth embodiment of a transducer, according to the invention;

FIGs. 13A-13G are schematic cross-sectional views of steps in one embodiment of a method of making the transducer of FIG. 12, according to the invention;

FIG. 14A is a schematic partial exploded view of an arrangement of multiple transducers corresponding to a fifth embodiment according to the invention;

FIGs. 14B and 14C are schematic front and side views of the transducer of FIG. 14A, according to the invention;

FIG. 15A is a schematic exploded view of a sixth embodiment of a transducer, according to the invention;

FIG. 15B is a schematic cross-section view of the transducer of FIG. 15A, according to the invention;

FIG. 16 is a schematic cross-sectional view of a seventh embodiment of a transducer, according to the invention; and

FIGs. 17A-17F are schematic cross-sectional views of steps in one embodiment of a method of making the transducer of FIG. 16, according to the invention.

DETAILED DESCRIPTION

[0010] The present invention is directed to the area of transducers for ultrasound imaging systems, devices and systems containing the transducers, and methods of making and using the transducers. The present invention is also directed to transducers for an intravascular ultrasound imaging system.

[0011] Suitable intravascular ultrasound ("IVUS") imaging systems include, but are not limited to, one or more transducers disposed on a distal end of a catheter configured and arranged for percutaneous insertion into a patient. Examples of IVUS imaging systems with catheters are found in, for example, U.S. Patents Nos. 7,246,959; 7,306,561; and 6,945,938; as well as U.S. Patent Application Publication Nos. 20060253028; 20070016054; 20060106320; 20070038111; 20060173350; and 20060100522, all of which are incorporated by reference.

[0012] Figure 1 illustrates schematically one embodiment of an IVUS imaging system 100. The IVUS imaging system 100 includes a catheter 102 that is coupleable to a control module 104. The control module 104 may include, for example, a processor 106, a pulse generator 108, a motor 110, and one or more displays 112. In at least some embodiments, the pulse generator 108 forms electric pulses that may be input to one or more transducers (312 in Figure 3) disposed in the catheter 102. In at least some embodiments, mechanical energy from the motor 110 may be used to drive an imaging core (306 in Figure 3) disposed in the catheter 102. In at least some embodiments, electric pulses transmitted from the one or more transducers (312 in Figure 3) may be input to the processor 106 for processing. In at least some embodiments, the processed electric pulses from the one or more transducers (312 in Figure 3) may be displayed as one or more images on the one or more displays 112. In at least some embodiments, the processor 106 may also be used to control the functioning of one or more of the other components of the control module 104. For example, the processor 106 may be used to control at least one of the frequency or duration of the electrical pulses transmitted from the pulse generator 108, the rotation rate of the imaging core (306 in Figure 3) by the motor 110, the velocity or length of the pullback of the imaging core (306 in Figure 3) by the motor 110, or one or more properties of one or more images formed on the one or more displays 112. In some embodiments, the parts of the control module 104 (*i.e.,* the processor 106, the pulse generator 108, the motor 110, and the one or more displays 112) may be in one unit. In other embodiments, the parts of the control module 104 are in two or more units.

[0013] Figure 2 is a schematic side view of one embodiment of the catheter 102 of the IVUS imaging system (100 in Figure 1). The catheter 102 includes an elongated member 202 and a hub 204. The elongated member 202 includes a proximal end 206 and a distal end 208. In Figure 2, the proximal end 206 of the elongated member

202 is coupled to the catheter hub 204 and the distal end 208 of the elongated member is configured and arranged for percutaneous insertion into a patient. In at least some embodiments, the catheter 102 defines at least one flush port, such as flush port 210. In at least some embodiments, the flush port 210 is defined in the hub 204. In at least some embodiments, the hub 204 is configured and arranged to couple to the control module (104 in Figure 1). In some embodiments, the elongated member 202 and the hub 204 are formed as a unitary body. In other embodiments, the elongated member 202 and the catheter hub 204 are formed separately and subsequently assembled together.

[0014] Figure 3 is a schematic perspective view of one embodiment of the distal end 208 of the elongated member 202 of the catheter 102. The elongated member 202 includes a sheath 302 and a lumen 304. An imaging core 306 is disposed in the lumen 304. The imaging core 306 includes an imaging device 308 coupled to a distal end of a rotatable driveshaft 310.

[0015] The sheath 302 may be formed from any flexible, biocompatible material suitable for insertion into a patient. Examples of suitable materials include, for example, polyethylene, polyurethane, polytetrafluoroethylene (PTFE), other plastics, and the like or combinations thereof.

[0016] One or more transducers 312 may be mounted to the imaging device 308 and employed to transmit and receive acoustic pulses. In a preferred embodiment (as shown in Figure 3), an array of transducers 312 are mounted to the imaging device 308. In other embodiments, a single transducer may be employed. In yet other embodiments, multiple transducers in an irregular-array may be employed. Any number of transducers 312 can be used. For example, there can be two, three, four, five, six, seven, eight, nine, ten, twelve, fifteen, sixteen, twenty, twenty-five, fifty, one hundred, five hundred, one thousand, or more transducers. As will be recognized, other numbers of transducers may also be used.

[0017] The one or more transducers 312 may be formed from one or more known materials capable of transforming applied electrical pulses to pressure distortions on the surface of the one or more transducers 312, and vice versa. Examples of suitable materials include piezoelectric ceramic materials, piezocomposite materials, piezoelectric plastics, barium titanates, lead zirconate titanates, lead metaniobates, polyvinylidenefluorides, lead magnesium niobate-lead titanates, and the like. These materials will be collectively referred to as "piezoelectric materials". Additionally, capacitive micromachined ultrasound transducers (CMUTs) or the like may be used.

[0018] Pressure distortions on the surface of the one or more transducers 312 can be generated in order to form acoustic pulses of a frequency based on the resonant frequencies of the one or more transducers 312. The resonant frequencies of the one or more transducers 312 may be affected by the size, shape, and material used to form the one or more transducers 312. The one or more transducers 312 may be formed in any shape suitable for positioning within the catheter 102 and for propagating acoustic pulses of a desired frequency or frequencies in one or more selected directions. For example, transducers may be disc-shaped, block-shaped, ring-shaped, layered, and the like. The one or more transducers may be formed in the desired shape by any process including, for example, dicing, machining, dice and fill, chemical etching, plasma etching, reactive ion etching, microfabrication, and the like.

[0019] In at least some embodiments, the one or more transducers 312 can be used to form a radial cross-sectional image of a surrounding space. Thus, for example, when the one or more transducers 312 are disposed in the catheter 102 and inserted into a blood vessel of a patient, the one more transducers 312 may be used to form an image of the walls of the blood vessel and tissue surrounding the blood vessel.

[0020] In at least some embodiments, the imaging core 306 may be rotated about a longitudinal axis of the catheter 102. As the imaging core 306 rotates, the one or more transducers 312 emit acoustic pulses in different radial directions. When an emitted acoustic pulse with sufficient energy encounters one or more medium boundaries, such as one or more tissue boundaries, a portion of the emitted acoustic pulse is reflected back to the emitting transducer as an echo pulse. Each echo pulse that reaches a transducer with sufficient energy to be detected is transformed to an electrical signal in the receiving transducer. The one or more transformed electrical signals are transmitted to the control module (104 in Figure 1) where the processor 106 processes the electrical-signal characteristics to form a displayable image of the imaged region based, at least in part, on a collection of information from each of the acoustic pulses transmitted and the echo pulses received. In at least some embodiments, the rotation of the imaging core 306 is driven by the motor 110 disposed in the control module (104 in Figure 1).

[0021] As the one or more transducers 312 rotate about the longitudinal axis of the catheter 102 emitting acoustic pulses, a plurality of images are formed that collectively generate a radial cross-sectional image of a portion of the region surrounding the one or more transducers 312, such as the walls of a blood vessel of interest and the tissue surrounding the blood vessel. In at least some embodiments, the radial cross-sectional image can be displayed on one or more displays 112.

[0022] In at least some embodiments, the imaging core 306 may also move longitudinally along the blood vessel within which the catheter 102 is inserted so that a plurality of cross-sectional images may be formed along a longitudinal length of the blood vessel. In at least some embodiments, during an imaging procedure the one or more transducers 312 may be retracted (*i.e.,* pulled back) along the longitudinal length of the catheter 102. In at least some embodiments, the motor 110 drives the pullback of the imaging core 306 within the catheter 102. In at least some embodiments, the motor 110 pullback distance of the imaging core is at least 5 cm. In at least some embodiments, the motor 110 pullback distance of the imaging core is at least 10 cm. In at least some embodiments, the motor 110 pullback distance of the imaging core is at least 15 cm. In at least some embodiments, the motor 110 pullback distance of the imaging core is at least 20 cm. In at least some embodiments, the motor 110 pullback distance of the imaging core is at least 25 cm.

[0023] The quality of an image produced at different depths from the one or more transducers 312 may be affected by one or more factors including, for example, bandwidth, transducer focus, beam pattern, as well as the frequency of the acoustic pulse. The frequency of the acoustic pulse output from the one or more transducers 312 may also affect the penetration depth of the acoustic pulse output from the one or more transducers 312. In general, as the frequency of an acoustic pulse is lowered, the depth of the penetration of the acoustic pulse within patient tissue increases. In at least some embodiments, the IVUS imaging system 100 operates within a frequency range of 1 MHz to 60 MHz.

[0024] In at least some embodiments, one or more conductors 314 electrically couple the transducers 312 to the control module 104 (*See* Figure 1). In at least some embodiments, the one or more conductors 314 extend along a longitudinal length of the rotatable driveshaft 310.

[0025] In at least some embodiments, the catheter 102 with one or more transducers 312 mounted to the distal end 208 of the imaging core 308 may be inserted percutaneously into a patient via an accessible blood vessel, such as the femoral artery, at a site remote from the selected portion of the selected region, such as a blood vessel, to be imaged. The catheter 102 may then be advanced through the blood vessels of the patient to the selected imaging site, such as a portion of a selected blood vessel.

[0026] In many conventional transducer arrangements, the transducer is coupled to the remainder of the system using a coaxial cable. One contact of the transducer is coupled to the conductor that runs through the center of the coaxial cable and the other contact of the transducer is coupled to the cylindrical shield of the coaxial cable. Such an arrangement can lead to an unbalanced electrical connection between the transducer and the other electronic components of the ultrasound system.

[0027] Moreover, the connections to the transducer are often made using conductive adhesive to avoid other wire attachment techniques, such as welding and soldering, that would raise the temperature of the heat-sensitive piezoelectric material of the transducer. Conductive adhesives, however, can be unreliable. For example, the adhesives may lose their ability to reliably attach the wires to the transducer when exposed to chemical sterilizing agents, such as ethylene oxide, which are often used to sterilize the ultrasound catheter between uses.

[0028] Figure 4 illustrates an alternative arrangement in which the transducer 412, disposed in the catheter 402, is coupled to the remainder of the electronics of the imaging system using a shielded twisted pair cable 420. The shielded twisted pair cable 420 includes two insulated wires 422, 424, that are twisted together along the cable, as well as a metal shield 426 that can be electrically grounded. One of the wires 422 can be coupled to a first contact of the transducer 412 and the other wire 424 can be coupled to a second contact of the transducer. This arrangement provides for a balanced electrical connection with the transducer. The transducer 412 can be any transducer including currently available transducers. The wires 420, 422 can be attached to the transducer using any suitable method including conductive adhesives. As described in more detail below, the transducer can be arranged to allow the wires to be attached using heat-generating techniques, such as welding, soldering, thermal compression bonding, and the like.

[0029] Figure 5 illustrates another arrangement in which a transducer 512, disposed in a catheter 502, is coupled to a shielded twisted pair cable 520 (with two wires 522, 524 and a conductive shield 526) using a modular fitting 530. In at least some embodiments of this arrangement, the transducer 512 includes contacts (not shown) that couple (e.g., using a conductive adhesive or simply by contact) to corresponding contacts (not shown) on the modular fitting 530. The contacts on the modular fitting 530 are electrically coupled to pads (not shown) to which the wires 522, 524 can be attached. The wires 522, 524 can be attached to the pads of the modular fitting using any suitable technique. In particular, heat-generating techniques can be used for attachment of the wires 522, 524 because the piezoelectric material of the transducer is sufficiently distant that the heat will not damage it. In at least some instances, the wires may be attached to the modular fitting before the transducer is attached to the modular fitting. A modular arrangement, such as that illustrated in Figure 5, may also allow the transducer 512 to be removed or replaced without detaching the wires of the twisted pair cable 520 from the transducer.

[0030] There are a variety of arrangements and methods for forming a transducer. Typically, transducers have a number of different components including a transducer element, made of piezoelectric material or the like, that is disposed between at least two metal layers (or contact layers) through which electrical signals are provided to cause the transducer to emit ultrasound energy. The metal layers also receive electrical signals from the transducer element when the element receives ultrasound signals. The transducer may also optionally include at least one backing layer, and optionally, at least one matching layer.

[0031] Any suitable transducer element can be used in the transducers disclosed herein. In general, the transducer element is made of a material, such as a piezoelectric material or the like, that converts electrical signals into ultrasound signals and vice versa. The transducer element, unless otherwise indicated, can be a single crystal transducer element or the transducer element can have one or more individual transducing members optionally separated by non-transducing material (see e.g., Figure 6) or any other suitable arrangement of transducing members.

[0032] The metal layers and contact layers can be formed using any suitable conductive material including metals, alloys, and multi-layer conductive arrangements (e.g., multiple layers of different metals or alloys). Any metal or alloy can be used. For biological applications (e.g., intravascular ultrasound (IVUS) imaging), preferably any exposed portion of the metal or contact layers is made of a material (such as gold, platinum, platinum/iridium alloy, or silver-filled epoxy) that does not corrode when exposed to biological fluids under typical operating conductions. These materials may be plated over other metals, such as copper, Ni/Cr, Ni/Zn, and the like that may otherwise corrode. For example, copper or Ni/Cr can be covered by gold.

[0033] The optional matching layer is made of a material that acoustically matches the transducer element to the biological environment. For example, the matching layer may facilitate matching the high acoustic impedance of the transducer element with the lower acoustic impedance of the surroundings, such as tissue and fluids within which the catheter is disposed. Any suitable material may be used including, but not limited to, parylene, epoxy, polyimide, other polymers, and the like.

[0034] In some embodiments, the matching layer is non-conductive. In other embodiments, particularly when the matching layer is disposed between the transducer element and a metal layer, the matching layer is conductive. The matching layer can be made conductive by using, for example, a conductive polymer or by including conductive particles (e.g., metal, graphite, or alloy particles) within the polymeric material of the matching layer.

[0035] The optional backing layer can be provided for a variety of purposes including, but not limited to, device stability, protection, acoustic matching, or acoustic absorption. The backing layer can be made using any suitable material including, but not limited to, parylene, epoxy, filled epoxies, other polymers, and the like. In some embodiments, the backing layer is non-conductive. In other embodiments, particularly when the backing layer is disposed between the transducer element and a metal layer, the backing layer is conductive. The backing layer can be made conductive by using, for example, a conductive polymer or by including conductive particles (e.g., metal, graphite, or alloy particles) within the polymeric material of the backing layer. Optionally, the backing layer may also function as a matching layer and be formed using a material that acoustically matches the transducer element.

[0036] The backing and matching layers may be disposed on other layers of the transducer using any suitable method. Examples of methods for forming the backing and matching layers include, but are not limited to, spin coating, dip coating, spraying, vacuum deposition, chemical deposition, sputtering, casting, and the like or even adhering a pre-made backing or matching layer to another layer using an adhesive.

[0037] Figure 6 illustrates one embodiment of a transducer element 602 that, when coupled to metal layers as described below, can be used to form a transducer. The transducer element 602 includes piezoelectric material 604 that forms multiple piezoelectric transducing members 606. Each of the transducing members is separated from the others by non-transducing material 610, such as epoxy, polyimide, silicon, alumina, and the like. In at least one embodiment, the transducer element is formed from a slab of piezoelectric material (typically disposed on a carrier) that is etched, scored, sliced, cut, diced, or otherwise separated into the individual transducing members. The non-transducing material may then be disposed between the transducing members using a suitable technique, such as coating methods.

[0038] The transducer element 602 also includes at least two non-conductive pads 608. Preferably, these pads are made of a heat-resistant material and, more preferably, are made of a material that does not readily conduct heat. For example, the pads can be made of epoxy, filled epoxy, and the like. For example, a low viscosity epoxy such as Epotek™ 301-2 (Epoxy Technology, Bilerica, MA) may be used. The pads 608 may be made of he same material as the non-transducing material 610 and may be formed using the same techniques as are used to dispose the non-transducing material between the transducing members.

[0039] These non-conductive pads 608 will be disposed below, or above, metal contact sites, as described in more detail below, so that the wires (see, e.g., wires 422, 424 of Figure 4) that couple the transducer to the remainder of the imaging system electronics can be attached using, for example, heat-based bonding techniques, such as, for example, laser welding, hot bar solder reflow, thermal compression bonding, gold ball bonding, other soldering or welding techniques, or other techniques that include the application of heat to attach the wires. The non-conductive pads 608 provide protection from heat to the piezoelectric material of the transducing members so that these wire attachment techniques can be used.

[0040] Figure 7 illustrates one embodiment of a transducer 700 that uses the transducer element 602 of Figure 6. The transducer element 602 includes the piezoelectric material 604 (formed as individual transducing members as illustrated in Figure 6, although this detail is not shown in Figure 7 for purposes of clarity) and the non-conductive pads 608. The transducer 700 includes a top metal layer 710 and a bottom metal layer 712. A metal pad 716 is disposed on the top of the transducer element 602, but is electrically isolated from the top metal layer 710 by a separation 720 (e.g., by the removal of conductive material between the metal pad and the top metal layer.).

The metal pad 716 is electrically coupled to the bottom metal layer 712 through a conductive via 718 that is formed by making a hole through at least the pad 608 and plating or filling the hole with metal or another suitable electrically conducting material. The portion 714 of the top metal layer 710 and the metal pad 716 are each disposed over one of the non-conductive pads 608 of the transducer element 602 and provide attachment sites for a wire (see Figure 4).

[0041] The metal layers 710, 712 can be disposed on the transducer element 602 using any suitable method including, but not limited to, electroless plating, electroplating, evaporation, sputtering, chemical or physical vapor deposition, and the like. The separation 720 between the top metal conductive layer 710 and the metal pad 716 can be formed using an suitable technique including patterning a metal layer disposed on the top of the transducer element 602 using a positive or negative photoresist and etching away, or otherwise removing, a portion of that metal layer to form the top metal layer 710 and the metal pad 716 with separation 720. Alternatively, the transducer element 602 may be masked prior to the deposition of the metal so that the separation 720 is formed with the deposition of the metal layer 710 and metal pad 716.

[0042] The via 718 can be formed by any suitable method including, but not limited to, drilling, plasma etching, chemical etching, laser ablating, sputter etching, or otherwise making a hole through at least the non-conductive pad 608 of the transducer element. In one embodiment, this hole is formed prior to disposing the top metal layer 710 or bottom metal layer 712 (or both) on the transducer element 602 so that the hole can be coated or filled with metal as the top or bottom metal layer is formed. It will be understood, however, that the hole can be opened and the via 718 coated or filled with metal after the top and bottom metal layers 710, 712 are formed.

[0043] Figure 8 illustrates one arrangement in which four transducers 700a, 700b, 700c, and 700d can be formed together and then separated along lines 780, 782. Such an arrangement permits the simultaneous patterning of a metal layer to form the top metal layer 710, metal pad 716, and separation 720 for all four transducers. It will be recognized that this arrangement can be repeated as a larger arrangement to prepare more than four transducers together.

[0044] Figure 9 illustrates an alternate arrangement for forming four transducers 700a', 700b', 700c' and 700d'. In this arrangement, instead of four vias, a single via 718' is provided. In addition, the separation 720' between the metal layer 710 and metal pad 716' may be circular, rather than square or rectangular, although it will be understood that in any of the embodiments in Figures 7-10, the separation can have any shape as long as the top metal layer 710 and metal pad 716, 716' are not in electrical contact. Figure 10 illustrates one of the transducers 700' of Figure 9 with the same elements as the transducer 700 of Figure 7 except that a portion 718' of the side surface of non-conductive pad 608 is coated with metal to electrically couple the metal pad 716 to the bottom metal conductive layer 712.

[0045] Any of the embodiments in Figures 7-10 can be bonded to a backing layer (preferably, attached to the bottom metal layer). This backing layer may also be an acoustic matching layer. In addition, an acoustic matching layer may be disposed over at least a portion of the top metal layer.

[0046] Figures 11A-11E illustrate an example of a transducer 750. Figures 11A and 11B are side views from opposing sides of the transducer. The transducer 750 includes a transducing element 752, a first patterned metal layer 754 (Figure 11C), a second patterned metal layer 756 (Figure 11D), a third patterned metal layer 758 (Figure 1 IE), and a backing layer 760. Figures 11C-11E correspond to the first, second, and third patterned metal layers, respectively, and are illustrated in an arrangement for generating multiple transducers (similar to the arrangements in Figures 8 and 9). Each transducer corresponds to one of the rectangular regions bounded by the dotted lines (e.g., lines 762, 764). Any transducer element can be used including, for example, the transducer element 602 of Figure 6 (although, for this example, the pads 608 are unnecessary and may be omitted or replaced with additional transducing elements.)

[0047] In forming this transducer, vias 766, 768 are formed through all of the layers of the transducer and either coated or filled with metal or alloy. When the transducers are separated from each other, each via 766, 768 will be exposed similar to the via 718' in Figure 10. In addition, a separation 770 is formed around via 766 in the first metal layer 754 and a separation is formed 772 around via 768 in the second metal layer 756. In the third metal layer 758, a separation 774 divides the layer 758 into a first contact 776 and a second contact 778. The respective separations in each metal layer can be formed as each of the metal layers is deposited or the respective separations can be formed by patterning and etching (or otherwise removing a portion of the metal) a previously formed metal layer.

[0048] The vias are generally made and coated/filled after forming each of the layers of the transducer. The via 766 couples the majority of second metal layer 756 to the second contact 778. The via 768 couples the majority of the first metal layer 754 to the first contact 776. The wires from the remainder of the electronics of the ultrasound system can be connected to the first and second contacts 776, 778 (see, e.g., Figure 4). The presence of the backing layer 760 may permit the use of heat-based attachment methods for attaching the wires to the first and second contact 776, 778 by protecting the transducer element 750 from the heat generated by attachment. This example also lends itself to electrical connection via preformed pads in the modular fitting 530 shown in Figure 5.

[0049] Figure 12 illustrates another arrangement of a transducer 800 with a transducer element 802 comprising piezoelectric regions 804 separated by non-piezoelectric regions 806. The transducer 800 also includes two metal layers 808 and 810; a matching layer 812, and a backing layer 814. The transducer 800 is coupled to the remainder of the device electronics via contact wires 816 and 818 that are disposed next to, or over, a non-piezoelectric region 806'.

[0050] Figures 13A-13G illustrate one embodiment of a method of making the transducer 800. It will be understood that a variety of other methods can be used to form the transducer 800. A piezoelectric material 804' is removably attached to a carrier 820 using any suitable technique including adhesives, waxes, and the like, as illustrated in Figure 13A. Cuts are formed in the piezoelectric material 804' to form piezoelectric regions 804, as illustrated in Figure 13B. The cuts can be formed using any suitable technique including coating the piezoelectric material 804' with a positive or negative photoresist; patterning and developing the photoresist to expose the portions of the piezoelectric material 804' to be removed; and etching the exposed piezoelectric material to form the cuts. Other methods for forming the cuts include, for example, wet chemical etching, reactive ion etching, plasma etching, microdicing, and the like. After the cuts are formed, the cuts can be filled with a suitable non-piezoelectric material, such as, for example, epoxy, filled adhesive, or the like, to form the non-piezoelectric regions 806, as illustrated in Figure 13B. Any suitable method for filling the cuts can be used including, for example, spin coating, dip coating, silkscreening, and the like. At least one of the non-piezoelectric regions 806' is formed for later use in coupling a wire 816 to the metal layer 808 over that region (see Figure 12) and may be larger than other non-piezoelectric regions.

[0051] The exposed surface of the piezoelectric regions 804 and non-piezoelectric regions 806 is metallized to generate metal layer 810, as illustrated in Figure 13C. The metallization can be performed using any suitable technique including, but not limited to, electroplating, electroless plating, sputtering, chemical or physical vapor deposition, and the like.

[0052] A backing layer 814 is formed over the metal layer 810, as illustrated in Figure 13D. The backing layer can be formed using any suitable technique including casting, chemical or physical vapor deposition, coating (e.g., spin coating, dip coating, sputtering), and the like. The backing layer is typically formed using a non-conductive material and preferably is used to acoustically match the piezoelectric material.

[0053] The carrier layer 820 is removed, as illustrated in Figure 13E. A second metal layer 808 is formed over the exposed at least a portion of the exposed surface of the piezoelectric regions 804 and non-piezoelectric regions 806, as illustrated in Figure 13F. The metallization can be performed using any suitable technique including, but not limited to, electroplating, electroless plating, sputtering, chemical or physical vapor deposition, and the like. A portion 822 of the exposed surface of the piezoelectric regions 804 may be left exposed by masking the portion of the surface prior to form the metal layer 808. Alternatively or additionally, the portion 822 of the exposed surface of the piezoelectric regions 804 may be exposed after forming the metal layer 808 by patterning and etching the metal layer using, for example, a positive or negative photoresist.

[0054] The exposed portion 822 of the piezoelectric region 804 can be removed using an suitable technique, for example, selective etching the of the piezoelectric material 804, to expose a portion of the underlying metal layer 810, as illustrated in Figure 13G. A matching layer 812 is disposed over the metal layer 808 and, optionally, over the exposed portion of the metal layer 810, as also illustrated in Figure 13G. The matching layer can be formed by any suitable technique including, but not limited to, casting, chemical or physical vapor deposition, coating (e.g., spin coating, dip coating, sputtering), and the like. The matching layer is typically formed using a non-conductive material and is used to acoustically match the piezoelectric material.

[0055] A portion of the matching layer 812 is removed to exposed portions of the metal layer 808 and 810 to allow for attachment of wires 816 and 818, as illustrated in Figure 12. It should be noted that the wires 816 and 818 are not attached to portions of the metal layers 808 and 810 that are directly over or under a piezoelectric region 804. Accordingly, in at least some embodiments, heat-based attachment methods can be used to attach the wires 816 and 818 to the metal layers 808 and 810.

[0056] Figures 14A-14C illustrate another transducer 900 with top and bottom flexible circuit layers 902, 904; a transducer element 906; a matching layer 908; and a backing layer 910 (which may also function as a matching layer). Figure 14A is a partially exploded view of one example that includes multiple transducers that can be separated along the dotted lines. Figures 14B and 14C illustrate side views (taken along two orthogonal sides) of a single transducer.

[0057] The transducer element 906 may be a single crystal of piezoelectric material or any other suitable arrangement of piezoelectric material that can form a transducer element (see e.g., the transducer element of Figure 6 with or without the non-transducing pads). The matching layer 908 and can be formed using any suitable conductive material that is acoustically matched to the piezoelectric material. The backing layer 910 can be formed using any suitable conductive material and may, in at least some examples, be acoustically matched to the piezoelectric material of layer 906.

[0058] The flexible circuit layers 902, 904 are each formed from a non-conductive carrier substrate 920, 930, respectively, such as polyimide or any other suitable polymeric material, with metal traces 922, 924, 932, 934 formed on the top and bottom of the non-conductive carrier substrate and electrically coupled by at least one metallic via 926, 936 extending through the non-conductive base 920, 930. The metal traces can be made using a single metal or alloy or can be made using layers of metals or alloys. The metal traces can be patterned or may cover an entire surface of the carrier substrate. In one example, the conductive metal traces and vias are formed using copper and the exposed traces are then covered with Ni/Cr and then gold or another metal that is inert under physiological conditions. It will be understood that the via can be positioned anywhere within the flexible circuit layer (e.g., in the middle or along the edge of the flexible circuit layer).

[0059] Wires can then be coupled to the flexible circuit layers 902, 904 to electrically connect the transducer to the remaining electronics of the ultrasound system. The flexible circuit, matching layer, and backing layer separate the wires from the transducer element to reduce heating of the transducer element if a heat-based bonding method is used to attach the wires to the transducer.

[0060] Figures 15A and 15B illustrate another example of a transducer 1000. This transducer 1000 includes a transducer element 1002; a first metal layer forming separated contacts 1008, 1010; second and third metal layers 1004, 1006; backing layer 1012; matching layer 1014; carrier layer 1016; via 1018; non-conductive wall 1020; and vertical conductor 1022. Any suitable transducer element 1002 can be used including single crystal elements or transducer elements with multiple transducing members (as illustrated, for example, in Figure 6 with or without the non-transducing pads.)

[0061] The backing layer 1012 and matching layer 1014 can be made of the same or different materials. The backing layer 1012 in the illustrated example is conductive. In an alternative example, the matching layer can be disposed between the transducer element 1002 and the third metal layer 1004. In this alternative example, the matching layer 1014 is also conductive.

[0062] In at least some examples, the carrier layer 1016, metal layer 1006, and contacts 1008, 1010 can be any thin film or thick film circuit material. The carrier layer 1016 can be any suitable non-conductive substrate material including, but not limited to, polymeric materials and ceramic materials. The first metal layer is patterned to form the contacts 1008, 1010. This thick or thin film circuit can be bonded to the backing layer 1012 using any technique including, but not limited to, using conductive adhesive, conductive epoxy, and the like. In one example, the carrier layer 1016, metal layer 1006, and contacts 1008, 1010 are a ceramic thick film circuit.

[0063] The contact 1008 is electrically coupled to the metal layer 1006 through the conductive via 1018. The contact 1010 is coupled to the metal layer 1004 through the vertical conductor 1022. The non-conductive wall 1020 insulates the transducer element 1002 from the vertical conductor 1022. The non-conductive wall 1020 and vertical conductor 1022 can be attached to the other components using any suitable technique including, but not limited to, using conductive adhesive, conductive epoxy, and the like. In at least some examples, the vertical sidewall of the carrier layer 1016 adjacent to the vertical conductor 1022 is coated with metal to facilitate coupling the vertical conductor 1022 to the contact 1010. Wires to the remainder of the system electronics can be attached to the contact layers 1008, 1010. This example also lends itself to electrical connection via preformed pads in the modular fitting 530 shown in Figure 5.

[0064] Figure 16 illustrates another example of a transducer 1100. The transducer 1100 includes a transducer element 1102; metal layers 1104, 1106 with corresponding vertical contact pads 1108, 1110 for attachment of wires 1112, 1114; a backing layer 1116; and a matching layer 1118.

[0065] Figures 17A-17F illustrate one example of a method of making the transducer 1100. Transducer material 1102' is removably disposed on a carrier 1120, as illustrated in Figure 17A. A portion of the transducer material 1102' is then removed to form one or more vertical slots 1122, as illustrated in Figure 17B. Preferably, the vertical slots are between ½ to ¾ the thickness of the transducer material 1102'. For example, the transducer material 1102' can be patterned and etched using a positive or negative photoresist material or the transducer material 1102' can be cut or otherwise diced. A metal layer 1104 is formed over the transducer material 1102' and within the vertical slot(s) 1122, as illustrated in Figure 17C. The metal layer 1104 can be formed using any suitable method including, but not limited to, electroplating, electroless plating, sputtering, chemical or physical vapor deposition, and the like. Any suitable metal, alloy, or combinations thereof may be used. For example, the metal layer may be formed by plating the surface with Ni/Cr and then with gold. A backing layer 1116 is disposed over the metal layer 1104 and the carrier layer 1120 is removed, as illustrated in Figure 17D.

[0066] One or more vertical slots 1124 are then formed in the opposite side of the transducer material 1102' and then filled with metal, along with the formation of metal layer 1106, as illustrated in Figure 17E. Preferably, the vertical slots are between ½ to ¾ the thickness of the transducer material 1102'. As an example, the metal layer may be formed by plating the surface with Ni/Cr and then with gold. A matching layer 1118 is disposed over the metal layer 1106 and the construct is then diced apart along lines 1126, 1128 to expose contact layers 1108, 1110, as illustrated in Figures 17F and 16. This example also lends itself to electrical connection via preformed pads in the modular fitting 530 shown in Figure 5.

[0067] The above specification, examples and data provide a description of the manufacture and use of the composition of the invention. Many embodiments can be made without departing from the scope of the invention, as defined by the claims hereinafter appended.

Claims

1. An ultrasound transducer (700, 800), comprising:

a transducer element (602, 802) comprising a piezoelectric material configured and arranged to convert electrical energy to ultrasound energy, the transducer element (602, 802) further comprising a first non-transducing pad (608, 806') defined in the transducer element (602, 802) and adjacent the piezoelectric material (604, 804);

a first metal layer (710, 810) disposed on a first surface of the transducer element (602, 802) and on the first non-transducing pad (608, 806'), wherein the non-transducing pad (608, 806') is configured and arranged to provide protection from heat to the piezoelectric material (604, 804) as a wire is attached to the first metal layer (710,810) above or below the non-transducing pad (608, 806') using a heat-based bonding technique; and

a second metal layer (712, 808) disposed on a second surface of the transducer element (602, 802) and on the first non-transducing pad (608, 806'), **characterised in that**

the piezoelectric material of the transducer element (602, 802) and the first non-transducing pad are disposed between the first metal layer and the second metal layer.

2. The ultrasound transducer of claim 1, further comprising

a second non-transducing pad (608) defined in the transducer element (602) and adjacent to the piezoelectric material (604) and

a metal pad (716) disposed over the second non-transducing pad (608) and in electrical communication with the second metal layer (710), wherein the second non-transducing pad (608) is configured and arranged to provide protection from heat to the piezoelectric material (604) as a wire is attached to the metal pad (716).

3. The ultrasound transducer of claim 2, wherein the metal pad (716) is disposed over a portion of the first surface of the transducer element (602).

4. The ultrasound transducer of claim 3, further comprising a metal via (718,718') through the transducer element (602) and coupling the metal pad (716) to the second metal layer (712).

5. The ultrasound transducer of claim 3, wherein the metal pad (716) and the first metal layer (710) are separated by an open separation region (720,720').

6. The ultrasound transducer of claim 2, wherein the first and second surfaces are opposing surface of the transducer element (602) and the metal pad is disposed on a third surface of the transducer element (602), wherein the third surface is between the first and second surfaces.

7. The ultrasound transducer of claim 2, wherein the first and second surfaces are opposing surface of the transducer element (602) and the metal pad (718, 718') extends along a third surface of the transducer element and onto the first surface of the transducer element (602), wherein the third surface is between the first and second surfaces.

8. The ultrasound transducer of claim 1, wherein the first metal layer (810) extends beyond the transducer element (802) to provide a contact pad configured and arranged for coupling of a wire (818) to the first metal layer (810) and the second metal layer (808) comprises a portion disposed over the first non-transducing pad (806) and configured and arranged for coupling of a wire (816) to the second metal layer (808).

9. The ultrasound transducer of claim 1, wherein the first metal layer extends beyond the transducer element to provide a contact pad configured and arranged for coupling of a first contact on a modular fitting of a catheter to the first metal layer and the second metal layer comprises a portion disposed over the first non-transducing pad and configured and arrange for coupling of a second contact on the modular fitting of the catheter to the second metal layer.

Patentansprüche

1. Ultraschallwandler (700, 800), aufweisend:

ein Wandlerelement (602, 802), das ein piezoelektrisches Material aufweist, welches zum Umwandeln von elektrischer Energie in Ultraschallenergie ausgebildet und eingerichtet ist, wobei das Wandlerelement (602, 802) ferner einen ersten nichtwandelnden Block (608, 806') aufweist, der in dem Wandlerelement (602, 802) definiert und neben dem piezoelektrischen Material (604, 804) angeordnet ist;

eine erste Metallschicht (710, 810), die auf einer ersten Oberfläche des Wandlerelements (602, 802) und auf dem ersten nichtwandelnden Block (608, 806') angeordnet ist, wobei der nichtwandelnde Block (608, 806') dazu ausgebildet und eingerichtet ist, dem piezoelektrischen Material (604, 804) Schutz vor Wärme zu bieten, wenn ein Draht über oder unter dem nichtwandelnden Block (608, 806') mit einer auf Wärme basierenden Klebetechnik an der ersten Metallschicht (710, 810) angebracht wird; und

eine zweite Metallschicht (712, 808), die auf einer zweiten Oberfläche des Wandlerelements (602, 802) und auf dem ersten nichtwandelnden Block (608, 806') angeordnet ist,

dadurch gekennzeichnet, dass das piezoelektrische Material des Wandlerelements (602, 802) und der erste nichtwandelnde Block zwischen der ersten Metallschicht und der zweiten Metallschicht angeordnet sind.

2. Ultraschallwandler nach Anspruch 1, ferner aufweisend:

einen zweiten nichtwandelnden Block (608), der im Wandlerelement (602) definiert und neben dem piezoelektrischen Material (604) angeordnet ist, und
eine Metallkontaktfläche (716), die über dem zweiten nichtwandelnden Block (608) angeordnet ist und in elektrischer Verbindung mit der zweiten Metallschicht (710) steht, wobei der zweite nichtwandelnde Block (608) dazu ausgebildet und eingerichtet ist, dem piezoelektrischen Material (604) Schutz vor Wärme zu bieten, wenn ein Draht an der Metallkontaktfläche (716) angebracht wird.

3. Ultraschallwandler nach Anspruch 2, wobei die Metallkontaktfläche (716) über einem Abschnitt der ersten Oberfläche des Wandlerelements (602) angeordnet ist.

4. Ultraschallwandler nach Anspruch 3, ferner aufweisend ein Metallkontaktloch (718, 718') das durch das Wandlerelement (602) hindurchtritt und die Metallkontaktfläche (716) mit der zweiten Metallschicht (712) koppelt.

5. Ultraschallwandler nach Anspruch 3, wobei die Metallkontaktfläche (716) und die erste Metallschicht (710) durch einen offenen Trennungsbereich (720, 720') voneinander getrennt sind.

6. Ultraschallwandler nach Anspruch 2, wobei die erste und zweite Oberfläche gegenüberliegende Oberflächen des Wandlerelements (602) sind und die Metallkontaktfläche auf einer dritten Oberfläche des Wandlerelements (602) angeordnet ist, wobei sich die dritte Oberfläche zwischen der ersten und der zweiten Oberfläche befindet.

7. Ultraschallwandler nach Anspruch 2, wobei die erste und zweite Oberfläche gegenüberliegende Oberflächen des Wandlerelements (602) sind und sich die Metallkontaktfläche (718, 718') entlang einer dritten Oberfläche des Wandlerelements und auf die erste Oberfläche des Wandlerelements (602) erstreckt, wobei sich die dritte Oberfläche zwischen der ersten und der zweiten Oberfläche befindet.

8. Ultraschallwandler nach Anspruch 1, wobei sich die erste Metallschicht (810) über das Wandlerelement (802) hinaus erstreckt, um eine Kontaktfläche zu bieten, die zum Ankoppeln eines Drahts (818) an die erste Metallschicht (810) ausgebildet und eingerichtet ist, und die zweite Metallschicht (808) einen über dem ersten nichtwandelnden Block (806) angeordneten Abschnitt aufweist, der zum Ankoppeln eines Drahts (816) an die zweite Metallschicht (808) ausgebildet und eingerichtet ist.

9. Ultraschallwandler nach Anspruch 1, wobei sich die erste Metallschicht über das Wandlerelement hinaus erstreckt, um eine Kontaktfläche zu bieten, die zum Ankoppeln eines ersten Kontakts auf einem modularen Anschlussstück eines Katheters an die erste Metallschicht ausgebildet und eingerichtet ist, und die zweite Metallschicht einen über dem ersten nichtwandelnden Block angeordneten Abschnitt aufweist, der zum Ankoppeln eines zweiten Kontakts auf einem modularen Anschlussstück eines Katheters an die zweite Metallschicht ausgebildet und eingerichtet ist.

Revendications

1. Transducteur d'ultra-sons (700, 800), comprenant :

un élément de transducteur (602, 802) comprenant un matériau piézo-électrique conçu et disposé pour convertir une énergie électrique en énergie ultrasonore, l'élément de transducteur (602, 802) comprenant en outre un premier bloc non transducteur (608, 806') défini dans l'élément de transducteur (602, 802) et adjacent au matériau piézo-électrique (604, 804) ;
une première couche métallique (710, 810) disposée sur une première surface de l'élément de transducteur (602, 802) et sur le premier bloc non transducteur (608, 806'), le bloc non transducteur (608, 806') étant conçu et disposée de façon à fournir une protection contre la chaleur au matériau piézo-électrique (604, 804) lorsqu'un fil est fixé à la première couche métallique (710, 810) au-dessus ou en dessous du bloc non transducteur (608, 806') à l'aide d'une technique de liaison basée sur la chaleur ; et
une deuxième couche métallique (712, 808) disposée sur une deuxième surface de l'élément de transducteur (602, 802) et sur le premier bloc non transducteur (608, 806'),
caractérisé en ce que le matériau piézo-électrique de l'élément de transducteur (602, 802) et le premier bloc non transducteur sont disposés entre la première couche métallique et la deuxième couche métallique.

2. Transducteur d'ultra-sons selon la revendication 1, comprenant en outre

un deuxième bloc non transducteur (608) défini dans l'élément de transducteur (602) et adjacent au matériau piézo-électrique (604) et
un bloc métallique (716) disposé au-dessus du deuxième bloc non transducteur (608) et en communication électrique avec la deuxième couche métallique (710), le deuxième bloc non transducteur (608) étant conçu et disposé de façon à fournir une protection contre la chaleur au matériau piézo-électrique (604) lorsqu'un fil est fixé au bloc métallique (716).

3. Transducteur d'ultra-sons selon la revendication 2, dans lequel le bloc métallique (716) est disposé au-dessus d'une portion de la première surface de l'élément de transducteur (602).

4. Transducteur d'ultra-sons selon la revendication 3, comprenant en outre une voie métallique (718, 718') à travers l'élément de transducteur (602) et couplant le bloc métallique (716) à la deuxième couche métallique (712).

5. Transducteur d'ultra-sons selon la revendication 3, dans lequel le bloc métallique (716) et la première couche métallique (710) sont séparés par une région de séparation ouverte (720, 720').

6. Transducteur d'ultra-sons selon la revendication 2, dans lequel les première et deuxième surfaces sont des surfaces opposées de l'élément de transducteur (602) et le bloc métallique est disposé sur une troisième surface de l'élément de transducteur (602), la troisième surface se trouvant entre les première et deuxième surfaces.

7. Transducteur d'ultra-sons selon la revendication 2, dans lequel les première et deuxième surfaces sont des surfaces opposées de l'élément de transducteur (602) et le bloc métallique (718, 718') s'étend le long d'une troisième surface de l'élément de transducteur et sur la première surface de l'élément de transducteur (602), la troisième surface se trouvant entre les première et deuxième surfaces.

8. Transducteur d'ultra-sons selon la revendication 1, dans lequel la première couche métallique (810) s'étend au-delà de l'élément de transducteur (802) afin de fournir un bloc de contact conçu et disposé pour le couplage d'un fil (818) à la première couche métallique (810) et la deuxième couche métallique (808) comprend une portion disposée au-dessus du premier bloc non transducteur (806) et conçue et disposée pour le couplage d'un fil (816) à la deuxième couche métallique (808).

9. Transducteur d'ultra-sons selon la revendication 1, dans lequel la première couche métallique s'étend au-delà de l'élément de transducteur afin de fournir un bloc de contact conçu et disposé pour le couplage d'un premier contact sur un raccord modulaire d'un cathéter à la première couche métallique et la deuxième couche métallique comprend une portion disposée au-dessus du premier bloc non transducteur et conçue et disposée pour le couplage d'un deuxième contact sur le raccord modulaire du cathéter à la deuxième couche métallique.

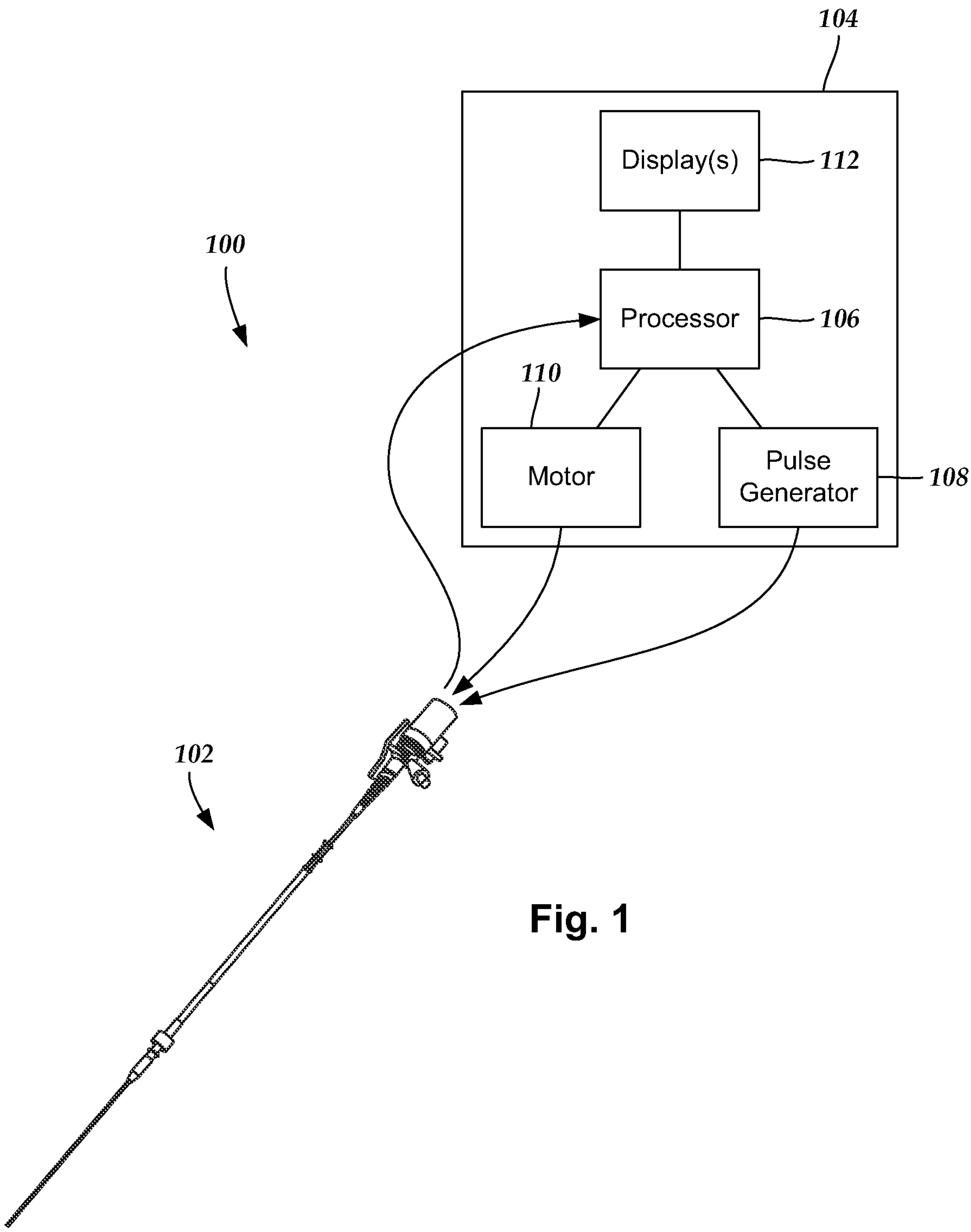
104
Display(s)
112
100
Processor
106
110
Motor
Pulse
Generator
108
102

Fig. 1

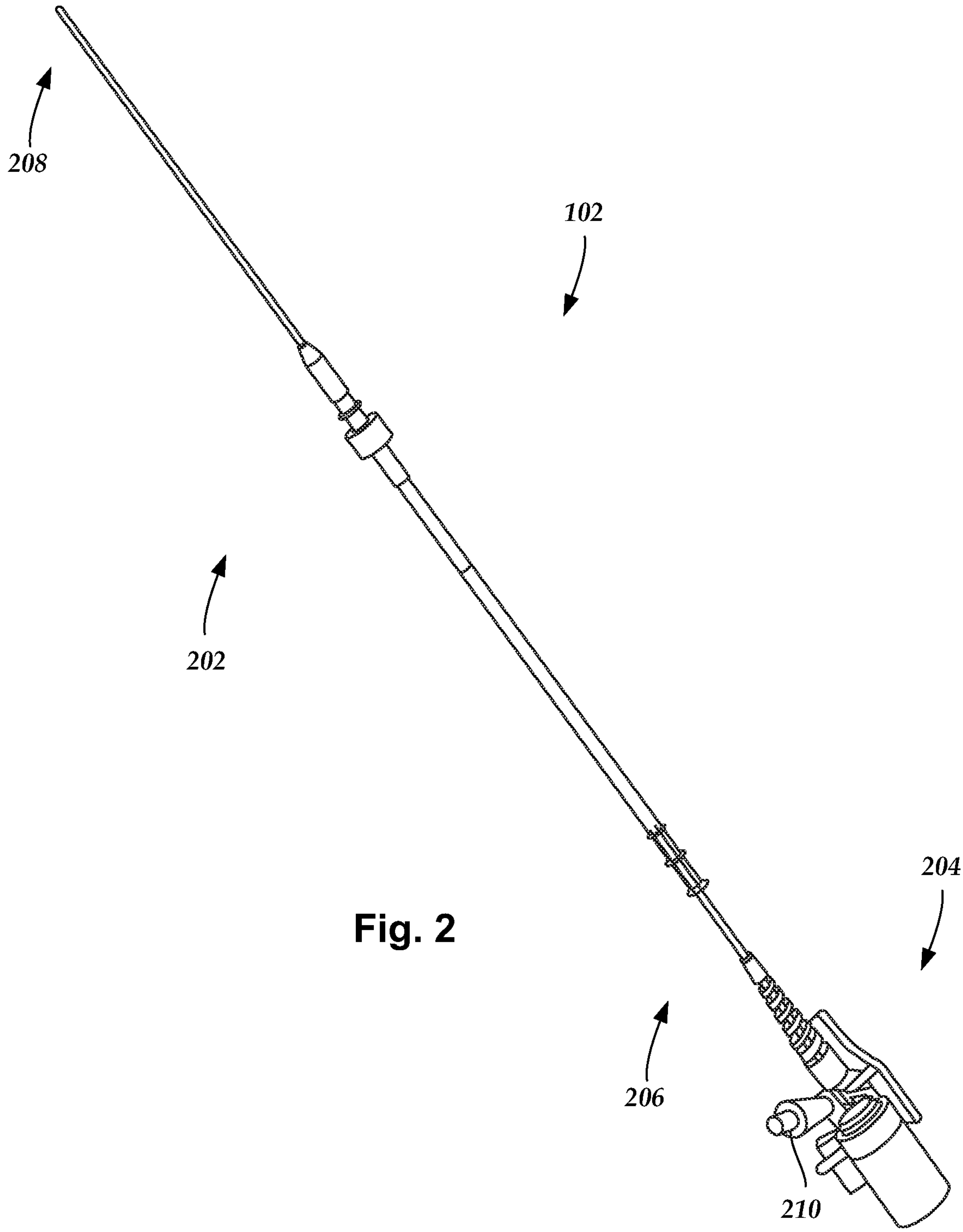

Fig. 2

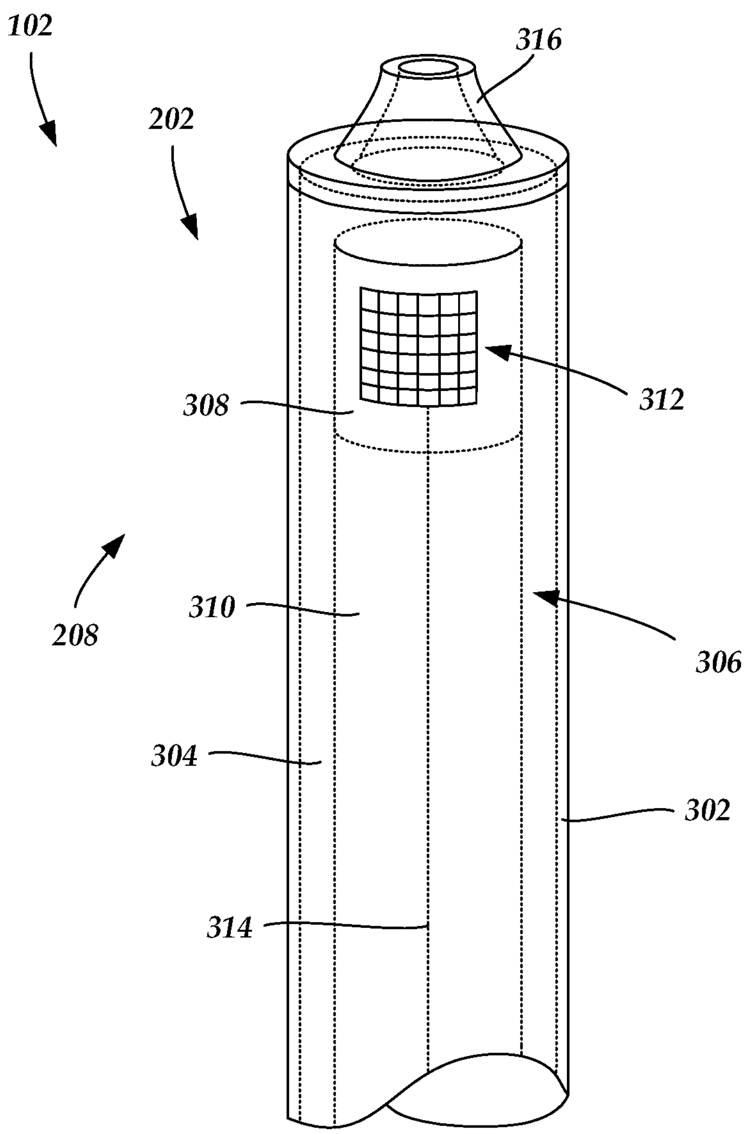

Fig. 3

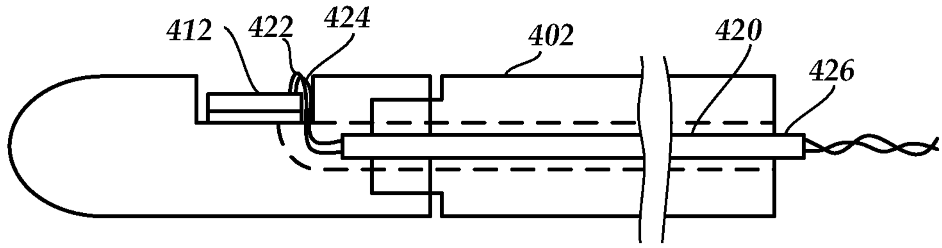

Fig. 4

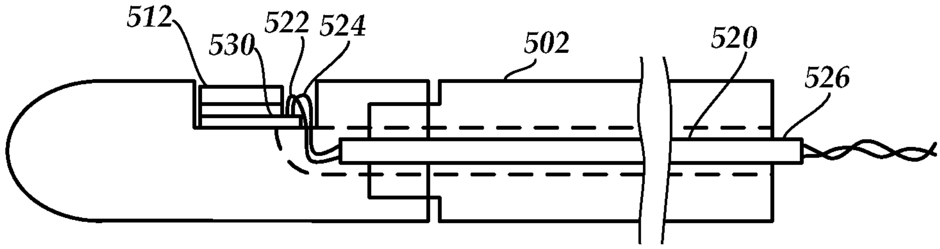

Fig. 5

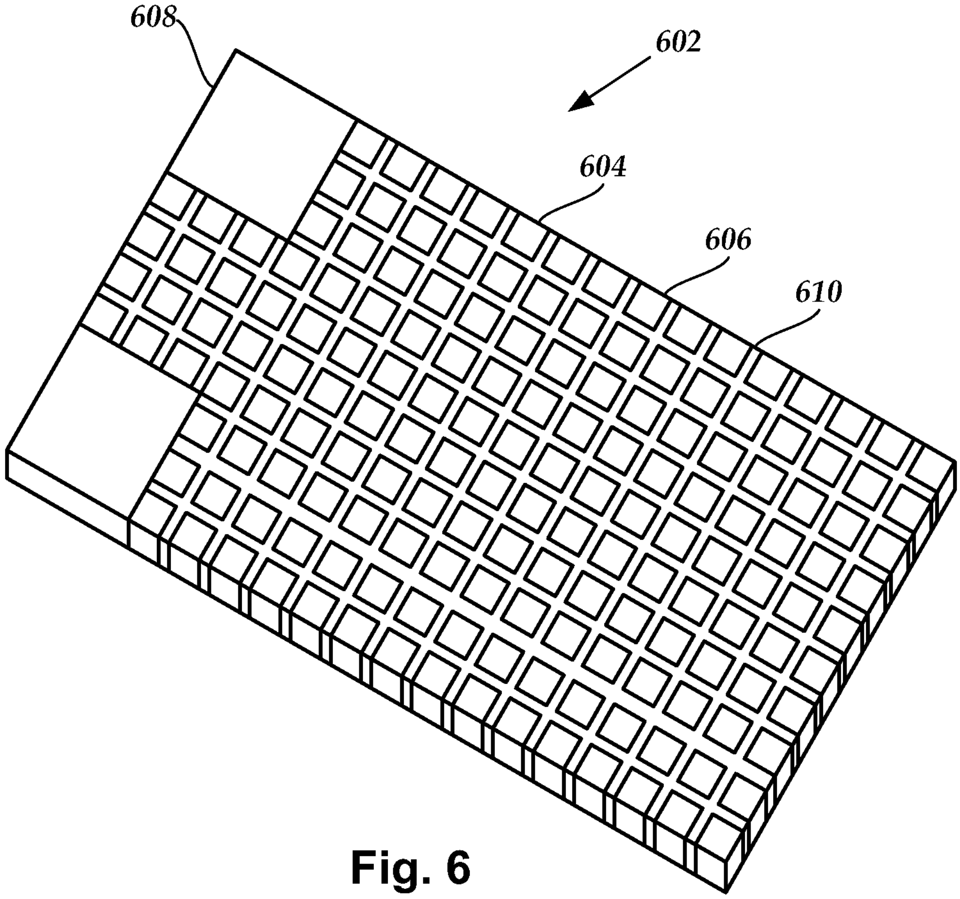

Fig. 6

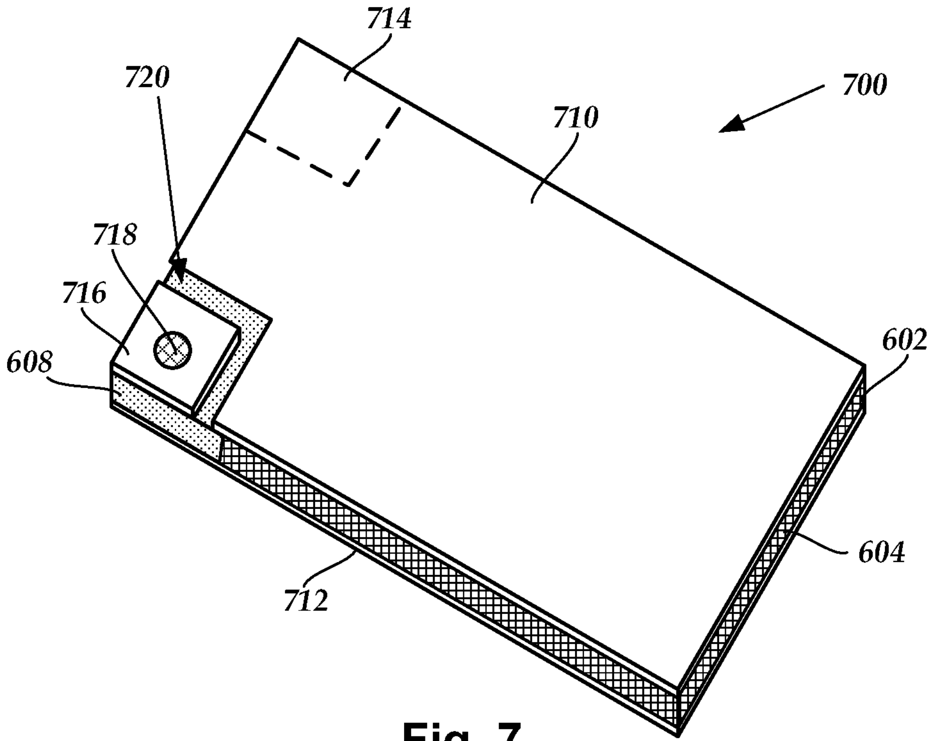
714
720
700
710
718
716
608
602
604
712

Fig. 7

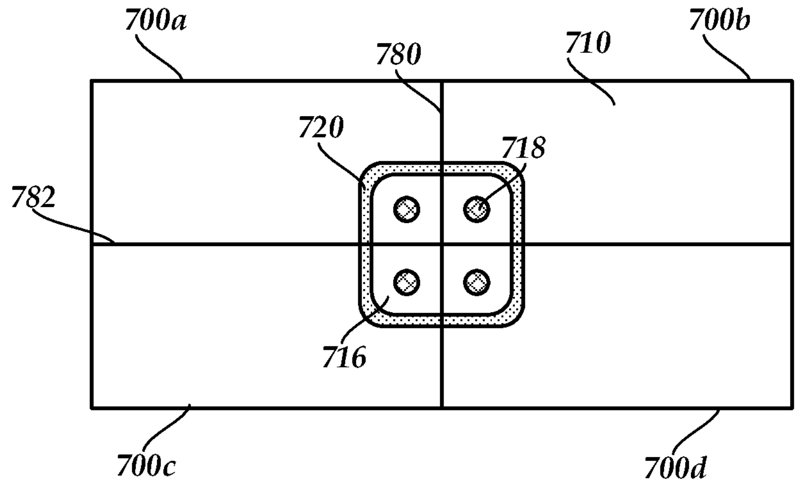
700a
780
710
700b
720
718
782
716
700c
700d

Fig. 8

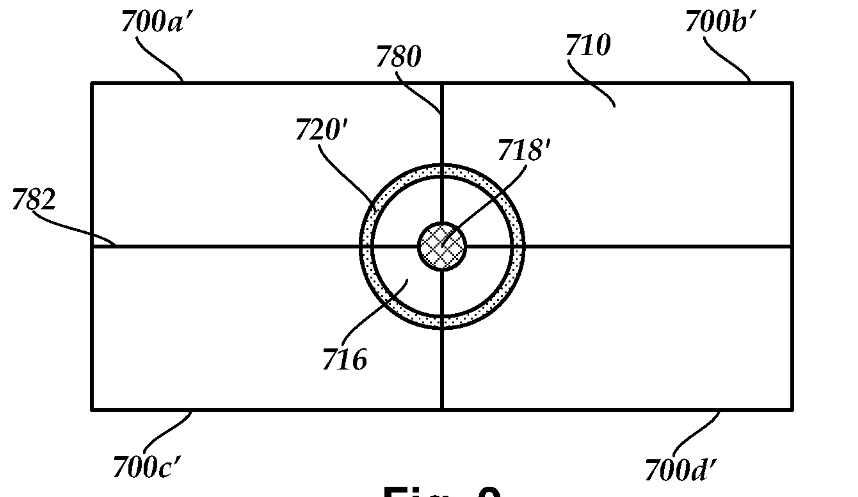
700a'
780
710
700b'
720'
718'
782
716
700c'
700d'

Fig. 9

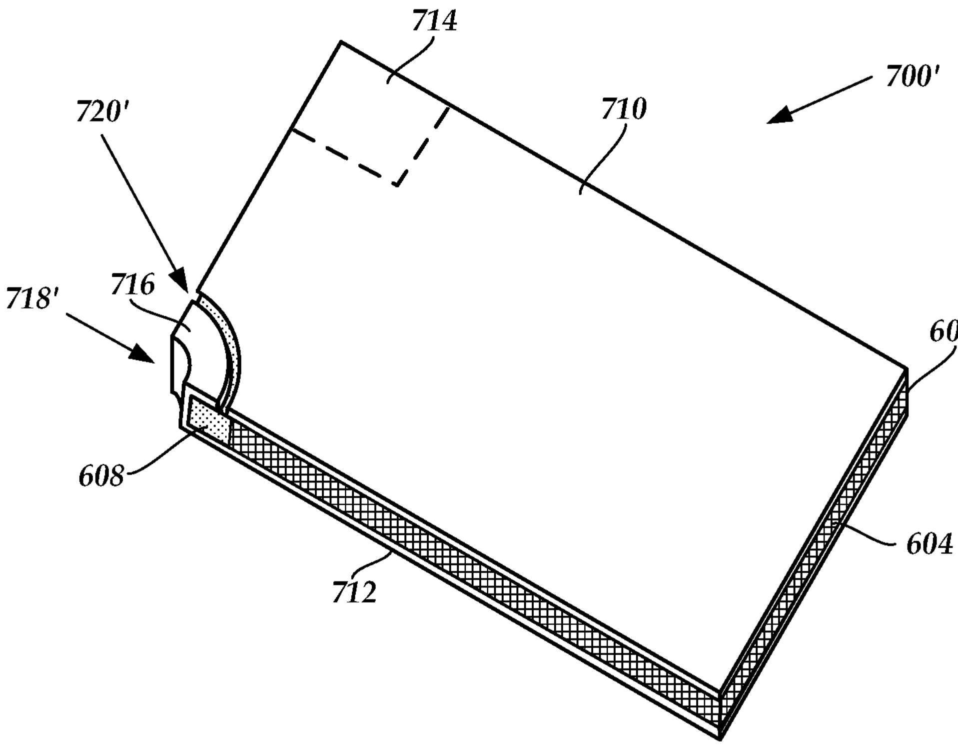
714
700'
720'
710
718'
716
602
608
604
712

Fig. 10

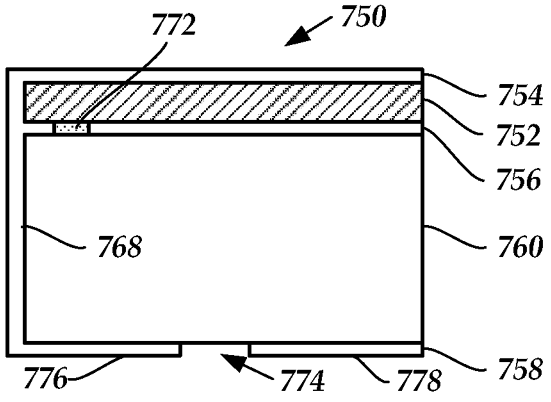

Fig. 11A

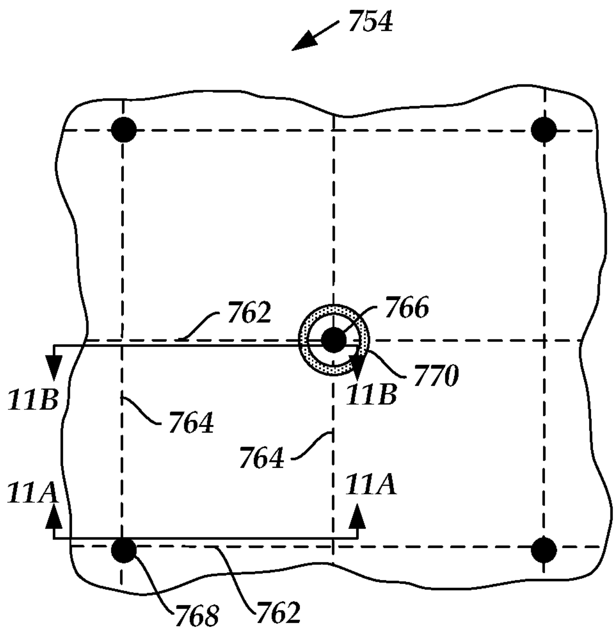

Fig. 11C

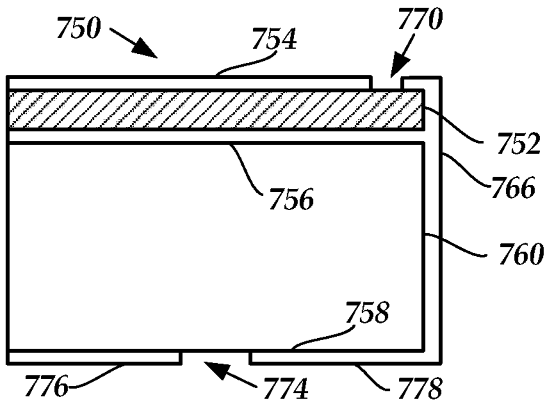

Fig. 11B

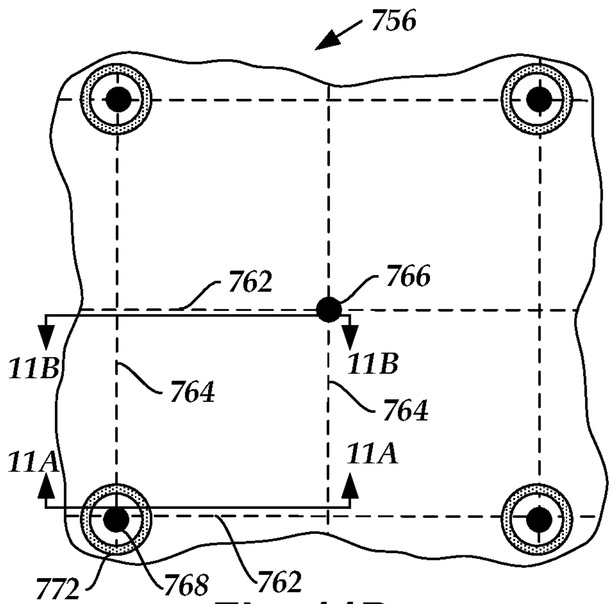

Fig. 11D

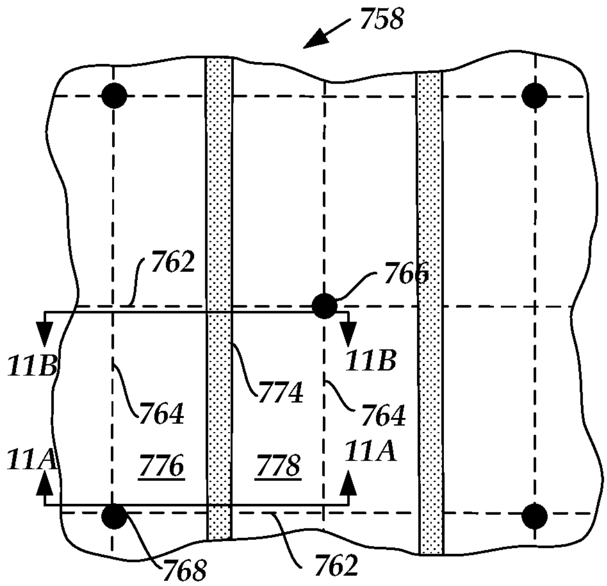

Fig. 11E

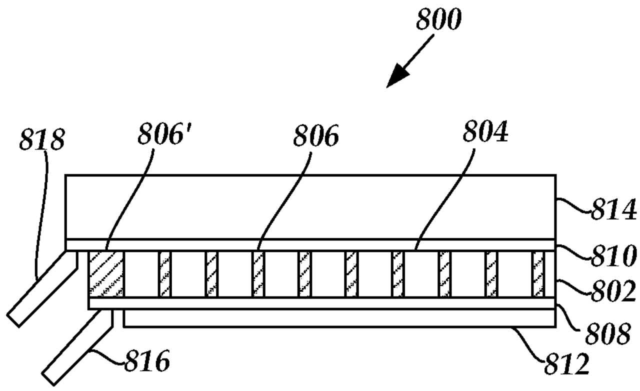

Fig. 12

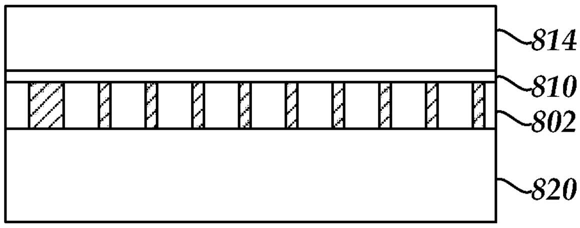

Fig. 13D

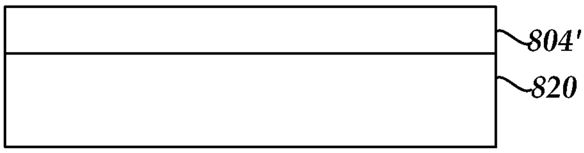

Fig. 13A

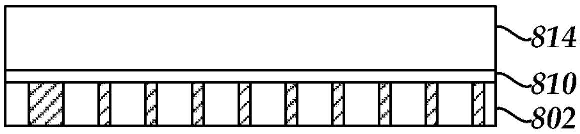

Fig. 13E

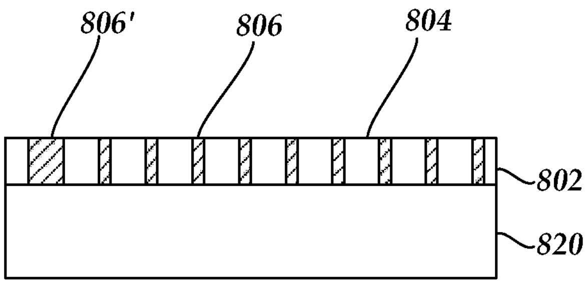

Fig. 13B

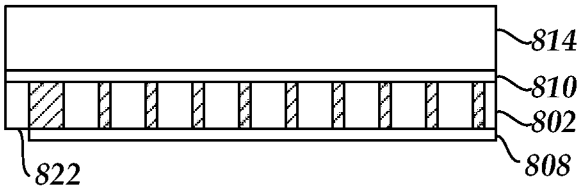

Fig. 13F

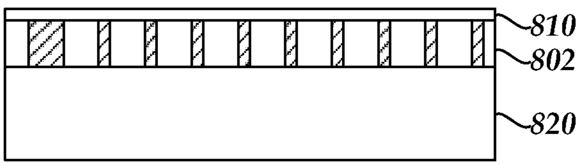

Fig. 13C

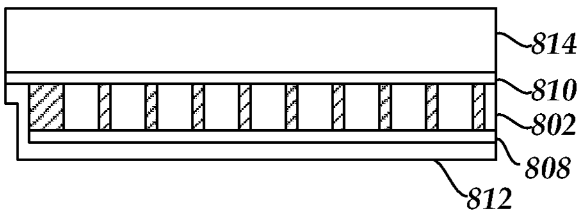

Fig. 13G

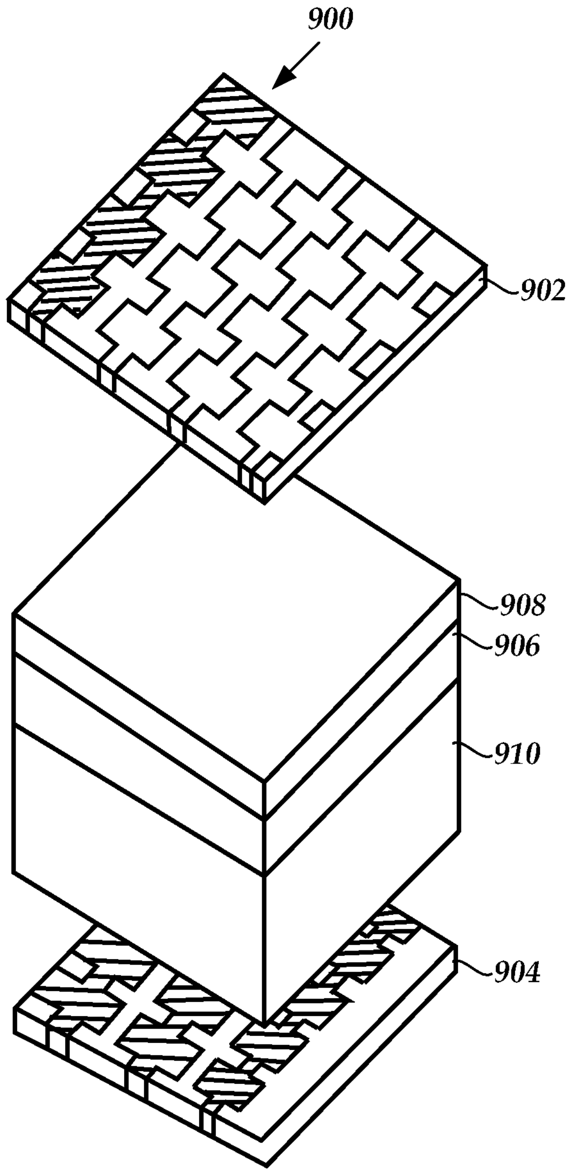

Fig. 14A

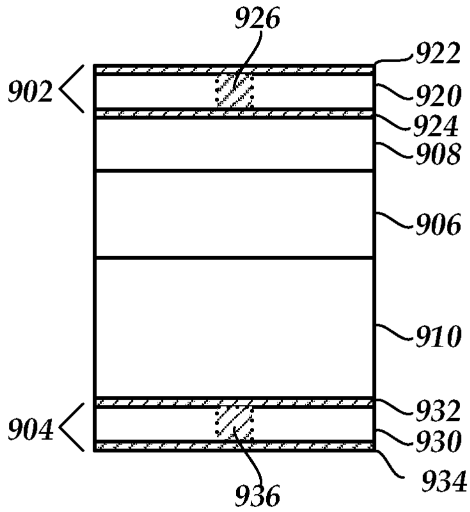

Fig. 14B

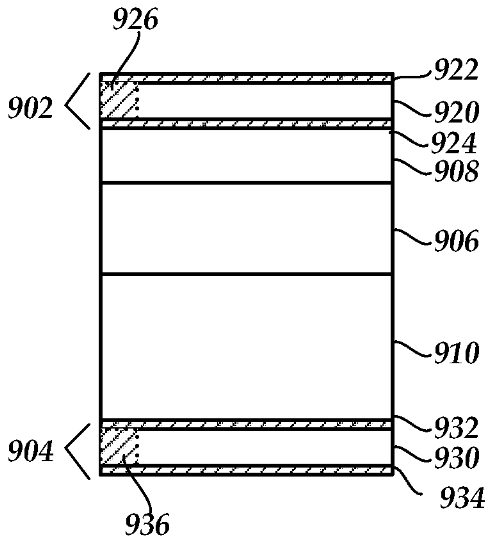

Fig. 14C

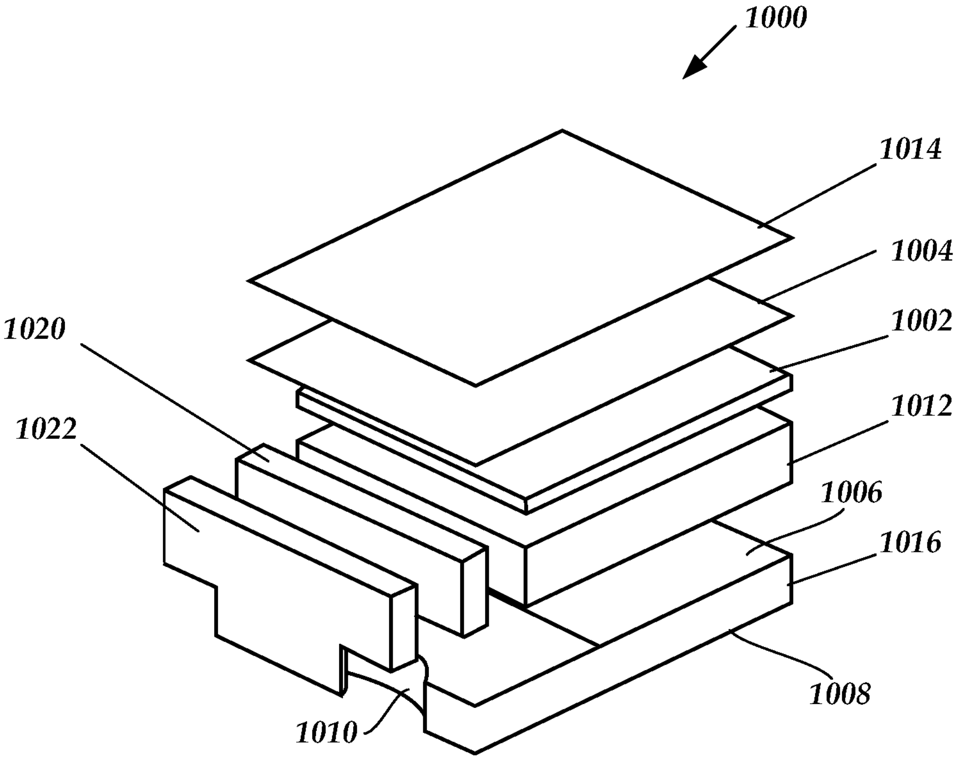

Fig. 15A

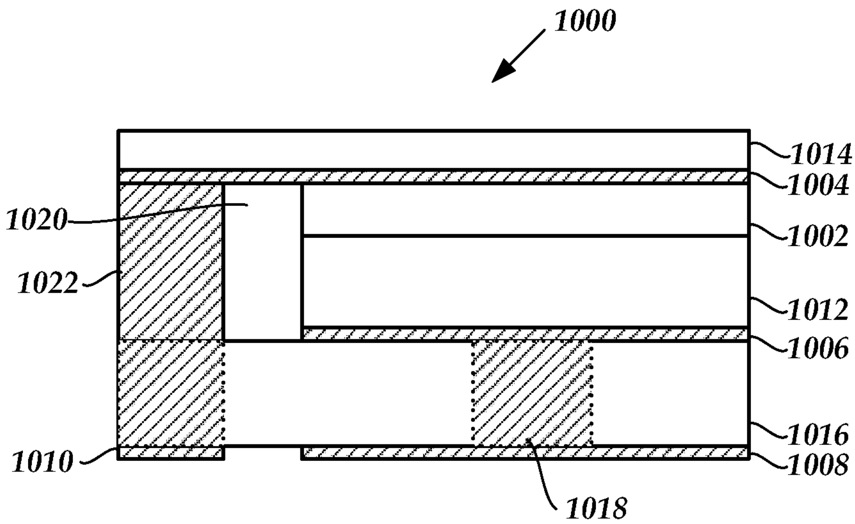

Fig. 15B

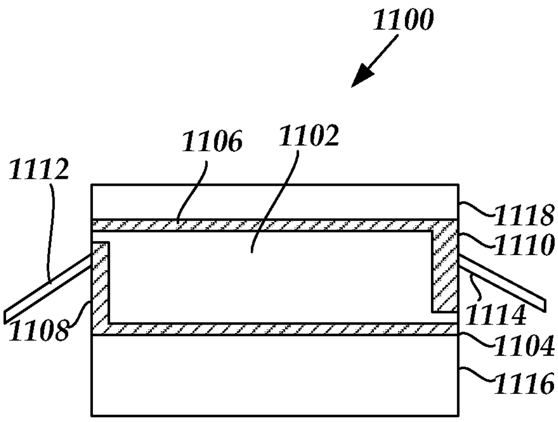

Fig. 16

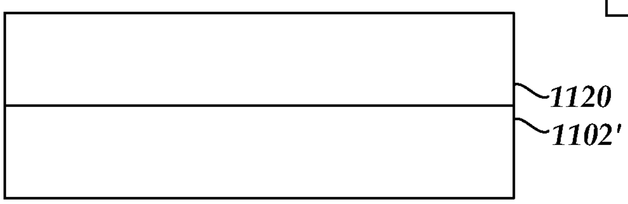

Fig. 17A

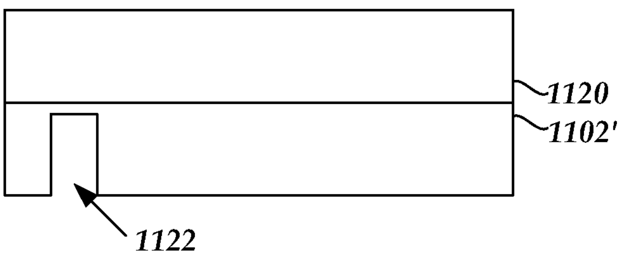

Fig. 17B

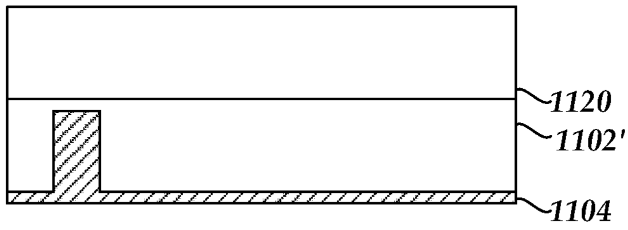

Fig. 17C

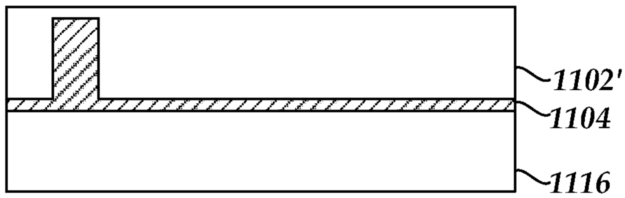

Fig. 17D

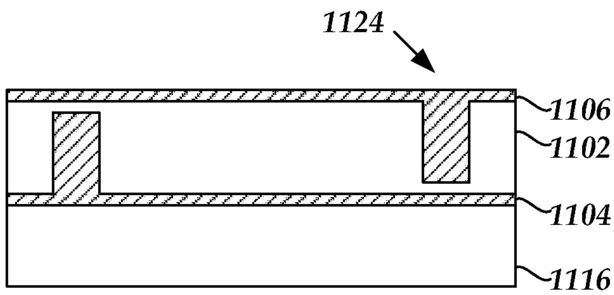

Fig. 17E

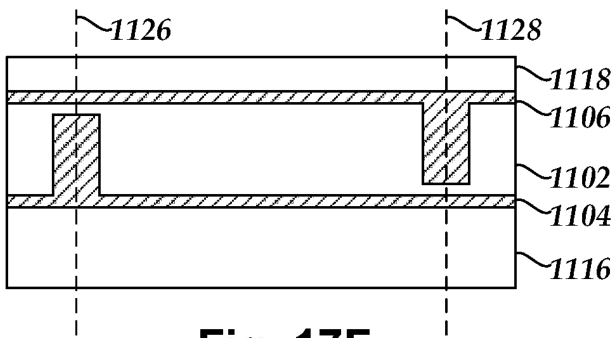

Fig. 17F

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H0647045 B **[0004]**
- US 4651310 A **[0005]**
- US 7246959 B **[0011]**
- US 7306561 B **[0011]**
- US 6945938 B **[0011]**
- US 20060253028 A **[0011]**
- US 20070016054 A **[0011]**
- US 20060106320 A **[0011]**
- US 20070038111 A **[0011]**
- US 20060173350 A **[0011]**
- US 20060100522 A **[0011]**

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申请(专利权)人(译)	BOSTON SCIENTIFIC SCIMED , INC.		
当前申请(专利权)人(译)	BOSTON SCIENTIFIC SCIMED , INC.		
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外部链接	Espacenet		

摘要(译)

用于血管内超声系统的导管组件包括导管和成像芯。导管包括内腔，该内腔沿着导管的纵向长度从近端延伸到远端，并且成像芯被配置和布置成用于插入到内腔中。成像芯包括可旋转的驱动轴，至少一个安装在可旋转的驱动轴的远端上的换能器，以及连接到至少一个换能器的双绞线。另外，提出了许多不同的换能器布置和制造换能器的方法。

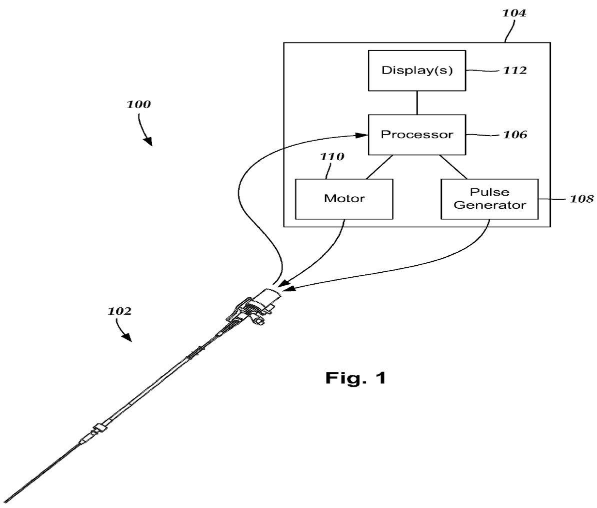

Fig. 1