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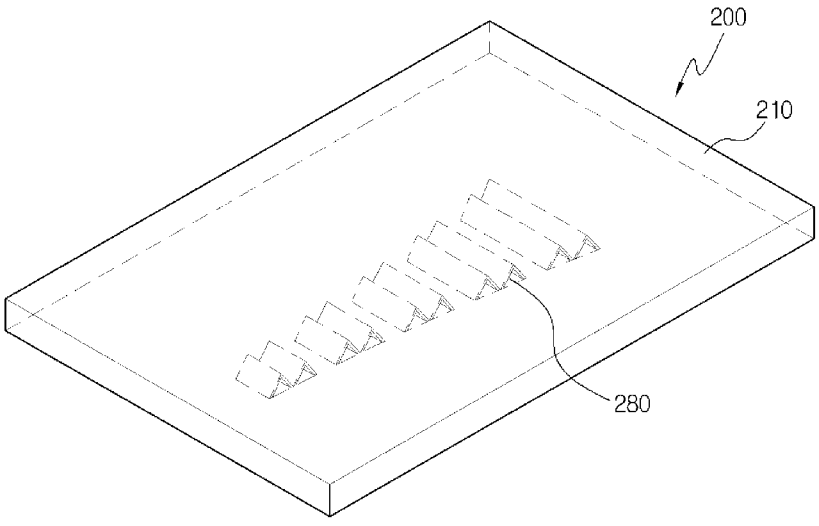
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(54) Title: METHOD FOR FABRICATING FREQUENCY ASSEMBLY-TYPE SEPARATING APPARATUS FOR COCHLEAR IMPLANT



(57) Abstract: A method for fabricating a frequency assembly-type separating apparatus for a cochlear implant includes: an upper layer fabrication step of including a step of fabricating an upper layer by coating an upper layer electrode unit on a substrate; a lower layer fabrication step of fabricating a lower layer by including a step of patterning a lower layer electrode unit on a basilar membrane formed on a base and a step of growing a nano-wire having piezoelectric characteristics on the lower layer electrode unit; and a coupling step of coupling the upper layer and the lower layer such that the upper layer electrode unit and the lower layer electrode unit are electrically connected.

Description

Title of Invention: METHOD FOR FABRICATING FREQUENCY ASSEMBLY-TYPE SEPARATING APPARATUS FOR COCHLEAR IMPLANT

Technical Field

[1] The present invention relates to a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant and, more particularly, to a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant capable of sensing a sound of a broad spectrum frequency band.

Background Art

[2] Various medical equipment helping those born deaf or deafened people have been developed. In particular, a cochlear implant system that helps to stimulate the auditory nerve of people whose auditory nerve is live with electricity to sense a sound is recognized as the most effective device among nerve assist devices developed so far, and cochlear implantations tend to increase yearly.

[3] The related art cochlear implant system includes an internal device inserted in a human body to simulate the auditory nerve and an external device receiving a sound at the outside of the human body. However, since separate equipment is required to be constantly attached to the outside of a human body, it takes a long time for a user to be accustomed thereto as part of his body and a third party may recognize it.

[4] Also, the related art cochlear implant system is limited to a sound of a frequency band that may be sensed due to a limited reception space of a human body, so even the use of the cochlear implant system has difficulty in recognizing an acoustic wave having a broad frequency band, merely helping daily lives by discriminating voices, and cannot sense a sound of a broad range of spectrum frequency band like music.

[5] The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

Disclosure of Invention

Technical Problem

[6] The present invention has been made in an effort to provide a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in which an upper layer and a lower layer on which nano-wire is grown are separately fabricated and compactly coupled to allow for recognizing an acoustic wave of a wideband

frequency.

Solution to Problem

[7] An exemplary embodiment of the present invention provides a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant including: an upper layer fabrication step of fabricating an upper layer by coating an upper layer electrode unit on a substrate; a lower layer fabrication step of fabricating a lower layer by including a step of patterning a lower layer electrode unit on a basilar membrane formed on a base and growing a nano-wire having piezoelectric characteristics on the lower layer electrode unit; and a coupling step of coupling the upper layer and the lower layer such that the upper layer electrode unit and the lower layer electrode unit are electrically connected.

[8] The coupling step comprises: forming a connection electrode unit electrically connected to the upper layer electrode unit; and coupling the upper layer and the lower layer such that the upper layer electrode unit and the lower layer electrode face each other.

[9] The coupling step may further include: forming a via hole to penetrate the substrate; coating an inner surface of the via hole with an electrical conductive material; and forming a connection electrode unit electrically connecting the via hole and the upper layer electrode unit on the substrate.

[10] The forming of the connection electrode unit may include: forming a first connection electrode unit extending from the upper layer electrode unit on the substrate; forming a second connection electrode unit on the base; and forming a third connection electrode unit having one end portion in contact with the first connection electrode unit and the other end portion in contact with the second connection electrode unit.

[11] In patterning the lower electrode unit, a central electrode having a width gradually increased in a length direction of the basilar membrane and an auxiliary electrode extending from the central electrode, which are spaced apart from one another, may be patterned.

[12] The lower layer fabrication step may further include: removing a portion of the layer provided on a lower surface of the basilar membrane to expose the lower surface of the basilar membrane.

[13] The growing of the nano-wire may include: laminating an upper surface of the basilar membrane with a photosensitizer; removing a portion of the photosensitizer to expose the central electrode to thereby make the central electrode become a seed layer; and growing a nano-wire by using the central electrode exposed to the outside as a seed layer.

[14] The growing of the nano-wire may include laminating an additional seed layer on on

the central electrode; and growing a nano-wire from the seed layer.

[15] The nano-wire may formed by growing a zinc oxide (ZnO) through a low temperature growth method. The method may further include coating upper portions of the nano-wire and the basilar membrane with a protective layer in order to prevent damage to the nano-wire after growing the nano-wire.

[16] The method may further include: exposing the nano-wire by removing the protective layer coated on an upper portion of the nano-wire, after exposing a lower surface of the basilar membrane.

[17] The upper layer fabrication step may include: forming a plurality of first pattern portions formed as the section of the substrate is depressed in a triangular shape, and spaced apart from each other; forming second pattern portions between the neighboring first pattern portions; and coating upper layer electrode units on the first pattern portions and the second pattern portions.

[18] The forming of the second portions may include: coating a buffer layer on the substrate between the neighboring first pattern portions; depositing a silicon dioxide ($Si0_2$) layer on an upper portion of the substrate; selectively removing the buffer layer and the silicon oxide layer from the region in which the buffer layer and the silicon dioxide ($Si0_2$) layer are simultaneously formed; etching a substrate region between neighboring silicon dioxide ($Si0_2$) layers to pattern the second pattern portions.

Advantageous Effects of Invention

[19] According to an embodiment of the present invention, the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant capable of precisely separating a frequency through vibration of the basilar membrane by separately fabricating the lower layer and the upper layer on which nano-wires are grown and coupling them is provided.

[20] Also, since the separate connection electrode unit connected to the upper layer electrode unit is patterned, although the upper layer is blocked against the outside as it is coupled to the lower layer, it can easily transfer an electrical signal to the outside through the connection electrode unit.

[21] Also, since the connection electrode unit is configured to be connected to the via hole completely penetrating the upper layer and an electrical signal is transferred to the outside through the via hole, the connection electrode unit is not exposed to the outside, obtaiing the overall compact configuration.

Brief Description of Drawings

[22] FIG. 1 is a view illustrating laminating first and second silicon layers in a lower layer fabrication step of a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to a first embodiment of the present

invention;

[23] FIG. 2 is a view illustrating patterning of a basilar membrane in the lower layer fabrication step of a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[24] FIG. 3 is a view illustrating pattering of a lower layer electrode unit in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[25] FIG. 4 is a view illustrating removing a portion of a first silicon layer in the lowr layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[26] FIG. 5 is a view illustrating forming a seed layer in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[27] FIG. 6 is a view illustrating growing nano-wires in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[28] FIG. 7 is a view illustrating coating a protective layer in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[29] FIG. 8 is a view illustrating removing portions of a second silicon layer and a base in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[30] FIG. 9 is a view illustrating removing a portion of the first silicon layer to expose a lower surface of a basilar membrane to the outside in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[31] FIG. 10 is a view illustrating a lower layer fabricated by the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[32] FIG. 11 is a view schematically illustrating a process of a modification of the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[33] FIG. 12 is a view schematically illustrating forming first pattern portions in an upper layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[34] FIG. 13 is a view schematically illustrating forming of second pattern portions in the upper layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[35] FIG. 14 is a view illustrating an upper layer fabricated by the method for fabricating

a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[36] FIG. 15 is a view schematically illustrating a frequency separating apparatus for a cochlear implant fabricated by the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1;

[37] FIG. 16 is a view schematically illustrating a frequency assembly-type separating apparatus for a cochlear implant fabricated by a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to a second embodiment of the present invention;

[38] FIG. 17 is a view illustrating an operation of the frequency assembly-type separating apparatus for a cochlear implant fabricated by a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to an embodiment of the present invention.

Mode for the Invention

[39] In several embodiments, the elements having the same configuration will be described representatively in a first embodiment by using the same reference numerals, and configurations different from that of the first embodiment will be described in the other embodiments.

[40] Hereinafter, a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to an embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[41] Meanwhile, drawings (b) in FIGS. 1 through 10 illustrate sections taken along line of (a) of the respective drawings.

[42] A frequency assembly-type separating apparatus 10 for a cochlear implant according to a first embodiment of the present invention includes a lower layer 100 and an upper layer 200. Thus, a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to the present embodiment includes a lower layer fabrication step, an upper layer fabrication step, and a coupling step of coupling upper and lower layers.

[43] Thus, first, a process of fabricating the upper and lower layers of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to the present embodiment will be described by stages, and the step of coupling the upper and lower layers will be described in detail.

[44] First, the lower layer fabrication step will be described.

[45] The lower layer 100 is configured such that a certain region of a basilar membrane 120 is vibrated according to a frequency band of an incoming acoustic wave, nanowires 150 grown on an upper portion of the basilar membrane 120 comes into contact with an upper layer electrode unit 280 of an upper layer 200 so as to be deformed to

generate an electrical signal from the nano-wires 150 by piezoelectric qualities.

[46] FIG. 1 is a view illustrating laminating first and second silicon layers in a lower layer fabrication step of a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to a first embodiment of the present invention.

[47] Referring to FIG. 1, in order to fabricate the lower layer 100, first, a base 110 is prepared. As the base 110, a double side polished (DSP) silicon wafer is used.

[48] A first silicon layer 111 is laminated on an upper surface of the base 110, and a second silicon layer 112 is laminated on a lower surface of the base 110. Here, in the present embodiment, a silicon oxide is used to form the first silicon layer 111 and the second silicon layer 112 laminated on the base 110, and in this step, the base 110 is put into a certain chamber, and a silicon oxide is laminated on the base 110 through a wet oxidation method in which steam is blown into the chamber while the chamber is heated.

[49] FIG. 2 is a view illustrating patterning of a basilar membrane in the lower layer fabrication step of a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[50] Referring to FIG. 2, the basilar membrane 120 is patterned on an upper surface of the first silicon layer 111 laminated on an upper surface of the base 110. The basilar membrane 120 is formed by depositing a silicon nitride (SiN) layer on an upper surface of the first silicon layer 111 by using low pressure chemical vapor deposition (LPCVD) and patterning the silicon nitride layer to have a certain form by using photolithography. In the present embodiment, the silicon nitride layer is patterned such that a plurality of basilar membranes 120 having a section with a quadrangular shape are positioned to be spaced apart from each other on the base 110.

[51] Namely, in this step, a plurality of basilar membranes 120 are prepared on the single base 110 configured as a silicon wafer, and each of the basilar membranes 120 is a constituent element of a single frequency assembly-type separating apparatus for a cochlear implant, and in this case, frequency assembly-type separating apparatuses 10 for a cochlear implant corresponding to the number of the basilar membranes 120 formed on the base 110 may be fabricated.

[52] FIG. 3 is a view illustrating pattering of a lower layer electrode unit in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[53] Referring to FIG. 3, after the basilar membrane 120 is patterned, a lower layer electrode unit 130 is patterned. The lower layer electrode unit 130 includes a plurality of central electrodes 131 and auxiliary electrodes 132 extending from the respective central electrodes 131.

[54] In the present embodiment, the lower layer electrode unit 130 is made of gold/titanium (Au/Ti) dual-layer metals by joining titanium (Ti) to a lower surface of gold (Au) which is firm and has high electrical conductivity in order to enhance bonding characteristics between gold (Au) and a different material. Thus, the lower layer electrode unit 130 is formed by depositing dual-layer metals comprised of gold (Au) and titanium (Ti) on the basilar membrane 120 and patterning the same by using photolithography.

[55] Meanwhile, the lower layer electrode unit 130 is patterned such that the central electrodes 131 and the auxiliary electrodes 132 are connected. Namely, a plurality of central electrodes 1331 are provided to be spaced apart in a length direction at the center of the basilar membrane 120 such that their width is gradually increased in the length direction of the basilar membrane 120. Also, the central electrodes 131 are patterned such that a virtual line formed by continuously connecting the middle points of the sides is a certain parabola or a linear line. Thus, a pair of parabolas or a pair of linear lines formed by continuously connecting the left and right sides of the central electrodes 131 form a virtual pyramid or a trapezoidal figure.

[56] The auxiliary electrodes 132 are mediums for transferring signals generated from the central electrodes 131 to the outside. The auxiliary electrodes 132 are provided to correspond to the number of the plurality of central electrodes 132, and extend from the respective central electrodes 131 so as to be elongated in a width direction of the basilar membrane 120. The auxiliary electrodes 132 may be formed on the basilar membrane 120 or may be formed to extend up to a region of the lower layer 100 outside the range of the basilar membrane 120.

[57] Meanwhile, upper surfaces of the central electrodes serve as seed layers for growing nano-wires 150, and as described above, the auxiliary electrodes 132 serve as mediums for connecting generated signals to an external signal processing unit, or the like.

[58] FIG. 4 is a view illustrating removing a portion of a first silicon layer in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[59] Referring to FIG. 4, after the lower layer electrode unit 130 is formed, a portion of the first silicon layer 111 on an upper surface of the base 110 is etched to be removed. Namely, in this step, only the first silicon layer 111 laminated on the region on which the basilar membrane 120 is not laminated is selectively removed.

[60] FIG. 5 is a view illustrating forming a seed layer in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[61] Referring to FIG. 5, in order to grow the nano-wires 150, only upper surfaces of the central electrodes 131 used as seed layers are exposed to the outside. First, the entire

upper surface of the base, namely, upper surfaces of the base 110, the basilar membrane 120, and the lower layer electrode unit 130 are coated with a photoresist 140. Thereafter, the photoresist 140 coated on the upper surfaces of the central electrodes 131 are removed through lift-off by using photolithography to expose the central electrodes 131 to the outside, and the exposed central electrodes 131 are used as seed layers for growing the nano-wires 150.

[62] FIG. 6 is a view illustrating growing nano-wires in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[63] Thereafter, referring to FIG. 6, a plurality of nano-wires 150 having piezoelectric characteristics are grown by using the respective upper surfaces of the plurality of central electrodes 131 exposed to the outside as seed layers. The nano-wires 150 are formed by a method of growing zinc oxide (ZnO) at a lwo temperature.

[64] FIG. 7 is a view illustrating coating a protective layer in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[65] Referring to FIG. 7, after the step of growing the nano-wires 150 is performed, upper surfaces of the central electrodes 131 including the nano-wires 150 are additionally coated with a photoresist to form a protective layer 180 in order to prevent the nano-wires from being damaged by external force or a chemical reaction in a follow-up process.

[66] A perfluoropoly ether (PFPE) layer 160 is deposited on an upper surface of the protective layer 180, and a carrier wafer 170 is coupled to an upper portion of the PFPE layer 160.

[67] FIG. 8 is a view illustrating removing portions of a second silicon layer and a base in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[68] Referring to FIG. 8, after the carrier wafer 170 is coupled, the basilar membrane 120 is processed such that a lower surface thereof is exposed to the outside to allow the basilar membrane 120 to be directly in contact with a propagation medium to receive an acoustic wave.

[69] Namely, a corresponding lower portion of the second silicon layer 112 is removed by using photolithography based on a virtual parabola formed by connecting the middle points of the respective sides of the plurality of central electrodes 131 as an outline. In this step, since a portion of the second silicon layer 112 is removed, a lower surface of the base 110 is exposed to the outside in the form of a trapezoid.

[70] A portion of the base 110 is selectively etched by using the second silicon layer exposed to the outside in the form of a trapezoid, as a mask. Here, the base 110 is

etched by using a deep reactive ion etching (RIE) process, and in this step, the base 110 is removed in the same trapezoidal shape as that of the second silicon layer 112 as described above, and a lower surface of the first silicon layer 111 provided on an upper surface of the base 110 is exposed to the outside.

[71] FIG. 9 is a view illustrating removing a portion of the first silicon layer to expose a lower surface of a basilar membrane to the outside in the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[72] Similarly, referring to FIG. 9, the first silicon layer 111 remaining on an upper surface of the base 110 is removed in the form of a trapezoid by using the base 110 as a mask. In this case, a buffered hydrofluoric acid (BHF) solution may be used to etch the first silicon layer 111.

[73] Thus, according to the foregoing step, the first silicon layer 111, the second silicon layer 112, and the base 110 provided below a lower surface of the basilar membrane 120 are removed in the form of a trapezoid, and the lower surface of the basilar membrane 120 is exposed in the form of a trapezoid to the outside.

[74] After the lower surface of the basilar membrane 120 is exposed to the outside, the carrier wafer 170 is removed, and the PFPE layer 160 is also removed by using an isopropyl alcohol (IPA).

[75] At the same time, in order to protect the nano-wires 150 from being damaged, the protective layer 180 coated on the upper surface of the basilar membrane 120 is removed by using acetone to expose the upper surface of the basilar membrane 120 and the nano-wires 150.

[76] Thus, according to this process, only a portion of the lower surface of the basilar membrane 120 is exposed in the form of a trapezoid to the outside, but the upper surface of the basilar membrane 120 is entirely exposed to the outside.

[77] FIG. 10 is a view illustrating a lower layer fabricated by the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[78] Referring to FIG. 10, according to the foregoing lower layer fabrication step, the lower layer 100 is formed such that the lower layer electrode unit 130 is formed at the center of an upper surface of the basilar membrane 120, the nano-wires 150 are grown by using the central electrodes 131 constituting the lower electrode unit 130, as seed layers, the lower surface of the basilar membrane 120 is processed to be exposed in the form of a virtual trapezoid formed by a virtual curve connecting the sides of the central electrodes 131, and an unexposed region of the lower surface of the basilar membrane 120 is upwardly supported by the second silicon layer 112.

[79] Meanwhile, in a modification of the lower layer fabrication step according to the present embodiment, a step of exposing the lower surface of the basilar membrane is

performed after the nano-wires are grown, but the lower layer may be fabricated in order of exposing the lower surface of the basilar membrane through processing and subsequently growing nano-wires.

[80] FIG. 11 is a view schematically illustrating a process of a modification of the lower layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1. As for the modification with reference to FIG. 11, after the lower electrode unit 130 is formed through the process illustrated in FIGS. 1 to 4, additional seed layers 150s are laminated on upper surfaces of the central electrodes 131 of the lower layer electrode unit fl30 as shown in FIG. 11(a). The seed layers 150s selectively laminated on the central electrodes are used as a basis for growing the nano-layer 150 later.

[81] Thereafter, as illustrated in FIG. 11(b), the PFPE layer 160 is deposited on an upper portion of the base 110, and the carrier wafer 170 is coupled to an upper portion of the PFPE layer 160.

[82] Subsequently, as illustrated in FIG. 11(c), portions of the first silicon layer 111, the second silicon layer 112, and the base 110 are removed to expose the lower surface of the basilar membrane 120, and then, the PFPE layer 160 and the carrier wafer 170 are removed.

[83] Finally, as illustrated in FIG. 11(d), the nano-wires are grown on the seed layers 150s additionally laminated on the central electrodes 131, thus fabricating the lower layer.

[84] Namely, according to the modification of the present embodiment, the process of opening the lower surface of the basilar membrane 120 is first performed relative to the growth of the nano-wires 150, thereby finally fabricating the lower layer 100.

[85] Hereinafter, the upper layer fabrication step will be described. The upper layer fabrication step includes forming a first pattern portion, forming a second pattern portion, and coating an upper layer electrode unit.

[86] First, the forming of the first pattern portion will be described.

[87] FIG. 12 is a view schematically illustrating forming first pattern portions in an upper layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[88] First, referring to FIG. 12(a), a DSP silicon wafer is prepared as a substrate 210, and the prepared substrate 210 is cleaned through an RCA cleaning method.

[89] Referring to FIG. 12(b), the cleaned substrate 210 is put into a certain chamber, and a first silicon dioxide ($Si0_2$) layer 220 is deposited on an upper surface of the substrate 210 through a wet-oxidation process as a method blowing steam into the chamber. Referring to FIG. 11(c), a photoresist is laminated on an upper surface of the deposited first silicon dioxide ($Si0_2$) layer 220 to form a first buffer layer 230.

[90] Referring to FIG. 12(d), the coated first buffer layer 230 is patterned into a plurality

of stripes repeatedly spaced apart from each other by using a photolithography method to selectively expose only the first silicon dioxide ($Si0_2$) layer 220 disposed on the lower surface of the first buffer layer 230 in a stripe shape.

[91] Referring to FIG. 12(e), the first silicon dioxide ($Si0_2$) layer 220 is etched by using the first buffer layer 230 remaining in the foregoing process as a mask by applying a buffered oxide etchant (BOE) solution to pattern the first silicon dioxide $Si0_2$ layer 220 in the same stripe form as that of the first buffer layer 230.

[92] Thereafter, referring to FIG. 12(f), the substrate 210 is etched by using the first silicon dioxide ($Si0_2$) layer 220 not etched in the foregoing process as a mask, and in this case, the substrate 210 is etched by potassium hydroxide (KOH), and thus, a plurality of first pattern portions 240 formed to be depressed in a shape of an inverted triangle are formed.

[93] Referring to FIG. 12(g), after the first pattern portions 240 are formed in the foregoing step, the first buffer layer 230 and the first silicon dioxide ($Si0_2$) layer 220 remaining in regions of the substrate 210 where the first pattern portions 240 are not formed.

[94] Next, a step of forming a second pattern portion will be described.

[95] FIG. 13 is a view schematically illustrating forming of second pattern portions in the upper layer fabrication step of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[96] Referring to FIGS. 13(a) and 13(b), a second buffer layer 250 formed of photoresist is laminated on the entire upper surface of the substrate 210, and portions of the second buffer layer 250 laminated on regions of the substrate 210 in which second pattern portions 270 are to be formed are selectively removed by using photolithography.

[97] Referring to FIG. 13(c), a second silicon dioxide ($Si0_2$) layer 260 is deposited on the entire upper surface of the substrate 210, namely, an upper surface of the second buffer layer 250 and an upper surface of the substrate 210 on which the first pattern portions 240 are fromed.

[98] Referring to FIG. 13(d), materials existing in regions in which both the second silicon dioxide ($Si0_2$) layer 260 and the second buffer layer 250 are laminated, excluding regions in which the second silicon dioxide ($Si0_2$) layer 260 is independently laminated are entirely removed from the substrate 210. Accordingly, the second silicon dioxide ($Si0_2$) layer 260 remains only in the regions of the substrate 210 in which the second pattern portions 270 are not to be formed, and the second silicon dioxide ($Si0_2$) layer 260 may be used as a mask for patterning the second pattern portion 270.

[99] Thus, referring to FIG. 13(e), the substrate 210 is etched with a section in the form of an inverse triangle by using the remaining second silicon dioxide ($Si0_2$) layer 260 as a

mask to form the second pattern portions 270. Thus, the second pattern portions 270 are prepared in regions between the mutually neighboring first pattern portions 240.

[100] Referring to FIG. 13(f), when the second silicon dioxide ($Si0_2$) layer 260 remaining so as to be used as a mask is entirely removed by using a BOE solution, the first pattern portions 240 and the second pattern portions 270 are simultaneously formed on the substrate 210.

[101] Referring to FIG. 13(g), in a step of coating the upper layer electrode unit 280, dual-layer metals of gold/titanium (Au/Ti) are coated on an outer surface of the substrate 210 with the first pattern portions 240 and the second pattern portions 270 formed thereon to form the upper layer electrode unit 280.

[102] FIG. 14 is a view illustrating an upper layer fabricated by the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[103] Referring to FIG. 14, the upper layer is configured such that the upper layer electrode unit 280 is formed in depressed regions of the substrate 280.

[104] Meanwhile, in the present embodiment as described above, after the first pattern portions are formed, the second pattern portions having the same shape are patterned between neighboring first pattern portions, thereby simultaneously coating the upper layer electrode unit on the first pattern portions and the second pattern portions, but the upper layer may be fabricated by coating the upper layer electrode unit only on the plurality of first pattern portions spaced apart from each other.

[105] Also, since the first pattern portions and the second pattern portions are to be configured to correspond to nano-wires formed on the lower layer electrode unit, the first pattern portions and the second pattern portions may be patterned to be in contact with each other or patterned to be spaced apart from each other according to nano-wires and a position and structure of the lower layer electrode unit.

[106] Next, the coupling step will be described.

[107] FIG. 15 is a view schematically illustrating a frequency separating apparatus for a cochlear implant fabricated by the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant in FIG. 1.

[108] Referring to FIG. 15, the coupling step may include forming a via hole, forming a connection electrode unit, and coupling the upper layer and the lower layer.

[109] First, a plurality of via-holes 320 are formed to be spaced apart from each other on the substrate 210, and an inner surface of the via holes 320 is coated with a conductive metal, e.g., dual-layer metals of gold/titanium (Au/Ti), to form a coated portion 330.

[110] In the forming of the connection electrode unit, in order to allow the upper layer electrode unit 280 formed on the upper layer 250 to be provided to the outside, a connection electrode unit 310 is formed as a medium for electrically connecting the upper layer electrode unit 280 and an external signal processing unit.

[111] Namely, the connection electrode units 310 electrically connecting the respective via holes 320 and the respective connection electrode units 310 corresponding to the respective via holes 320 are patterned on the substrate 210 by using the gold/titanium (Au/Ti) metals, to allow an electrical signal provided through the upper layer electrode unit 280 to be transferred to the via holes 320.

[112] Thus, when the upper layer 200 and the lower layer 100 are coupled, the upper layer electrode unit 280 is disposed to face the lower layer electrode unit 130. Thus, since it is difficult to directly transfer an electrical signal generated from the upper layer electrode unit 280, the electrical signal generated from the upper layer electrode unit 280 is transferred to an opposite surface of the substrate 210 on which the upper layer electrode unit 280 is formed through the via hole 320 completely penetrating the substrate 210.

[113] In the step of coupling the upper layer 200 and the lower layer 100, the upper layer 200 and the lower layer 100 are coupled such that the upper layer electrode unit 280 and the lower layer electrode unit 130 face each other and the respective nano-wires 150 grown on the lower layer electrode unit 130 are positioned in the depressed regions of the upper layer electrode unit 280.

[114] Also, the upper layer 200 is configured to have an area smaller than that of the lower layer 100, to allow a portion of the upper surface of the lower layer 100 to be exposed when coupled, whereby, preferably, the auxiliary electrode 132 of the lower electrode unit 130 is completely exposed to the outside.

[115] Meanwhile, the upper layer electrode unit 280 is electrically connected to a certain external signal analyzer 500 via the via hole 320, and the lower layer electrode unit 130 is directly connected to the signal analyzer 500 through the auxiliary electrode 132, so that electrical signals generated from the respective electrode units may be transferred to the signal analyzer 500.

[116] Next, a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to a second embodiment of the present invention will be described.

[117] FIG. 16 is a view schematically illustrating a frequency assembly-type separating apparatus for a cochlear implant fabricated by a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to a second embodiment of the present invention.

[118] Referring to FIG. 16, the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to a second embodiment of the present includes an upper layer fabrication step, a lower layer fabrication step, and a coupling step. The upper layer fabrication step and the lower layer fabrication step are the same as those described above in the first embodiment, so a repeated description

thereof will be omitted.

[119] The coupling step includes forming a connection electrode unit and coupling an upper layer and a lower layer.

[120] The forming of a connection electrode unit 410 is a step of forming the connection electrode unit 410 for electrically connecting an external signal processor to the upper layer electrode unit 280. The connection electrode unit 410 includes a first connection electrode unit 411, a second connection electrode unit 413, and a third connection electrode unit 412 connecting the first connection electrode unit 411 and the second connection electrode unit 413.

[121] First, the first connection electrode unit 411 is formed to extend from the upper layer electrode unit 280 on the same surface of the substrate 210 on which the upper layer electrode unit 280 is positioned. Also, the third connection electrode unit 413 is formed to protrusively extend downwardly from the first connection electrode unit 411.

[122] Finally, the second connection electrode unit 412 is patterned to extend in a certain direction by having an end portion at a position facing the first connection electrode unit on the same surface of the base 110 as that positioned on the lower layer electrode unit 130 of the lower layer 100 when the upper layer 200 and the lower layer 100 are coupled

[123] In the coupling of the upper layer 200 and the lower layer 100, the upper layer 200 and the lower layer 100 are coupled such that the upper layer electrode unit 280 and the lower layer electrode unit 130 are disposed to face each other and the nano-wires 150 extending from the lower layer electrode unit 130 are accommodated in a space formed by the upper layer electrode unit 280.

[124] Also, the upper layer 200 is formed to have an area smaller than that of the lower layer 100 to allow a portion of the upper surface of the lower layer 100 to be exposed when coupled, so that the auxiliary electrode 132 of the lower layer electrode unit 130 and the second connection electrode unit 132 are completely exposed to the outside.

[125] Thus, when the upper layer 200 and the lower layer 100 are coupled, the second connection electrode unit 413 is in contact with the third connection electrode unit and the third connection electrode unit 413 is electrically connected to the first connection electrode unit 411 electrically connected to the upper layer electrode unit 280, and thus, an electrical signal generated from the upper layer electrode unit 280 can be easily transferred to the outside through the connection electrode unit 410.

[126] Meanwhile, the upper layer electrode unit 280 is connected to the external signal analyzer 500 through the connection electrode unit 410, and the lower electrode unit 130 is directly connected to the signal analyzer 500 through the auxiliary electrode 132, whereby an electrical signal generated from each electrode unit may be transferred to the signal analyzer 500.

[127] Hereinafter, an operational principle of the frequency assembly-type separating apparatus for a cochlear implant fabricated according to the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to an embodiment of the present invention will be described briefly.

[128] FIG. 17 is a view illustrating an operation of the frequency assembly-type separating apparatus for a cochlear implant fabricated by a method for fabricating a frequency assembly-type separating apparatus for a cochlear implant according to an embodiment of the present invention.

[129] Referring to FIG. 17, in the frequency assembly-type separating apparatus for a cochlear implant 10, the upper layer 200 and the lower layer 100 are coupled such that the basilar membrane 120 of the lower layer 100 is supported by a certain propagation medium 600 and the upper layer electrode units 280 and the nano-wires 150 face each other.

[130] When an acoustic wave having a certain frequency is transferred through the propagation medium 600, a region of the basilar membrane 120 reacting to the frequency band of the acoustic wave flowing along the propagation medium 600 is deformed in response to the acoustic wave provided from the propagation medium 600.

[131] According to the reaction of the basilar membrane 120, the nano-wire 150 is reacted, and the nano-wire 150 comes into contact with the upper layer electrode unit 280 corresponding to an upper side thereof so as to be deformed to generate an electrical signal by piezoelectric qualities thereof. The generated electrical signal is transferred to the external signal analyzer to stimulate the auditory nerve corresponding to the frequency band of the acoustic wave, allowing a human body to sense a sound.

[132] Thus, in the case of the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant fabricated according to an embodiment of the present invention, an acoustic wave having a wideband frequency can be easily separated and analyzed, and transferred to the auditory nerve of a human body.

[133] While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

Industrial Applicability

[134] According to an embodiment of the present invention, the method for fabricating a frequency assembly-type separating apparatus for a cochlear implant capable of precisely separating a frequency through vibration of the basilar membrane by

separately fabricating the lower layer and the upper layer on which nano-wires are grown and coupling them is provided.

[135] Also, since the separate connection electrode unit connected to the upper layer electrode unit is patterned, although the upper layer is blocked against the outside as it is coupled to the lower layer, it can easily transfer an electrical signal to the outside through the connection electrode unit.

[136] Also, since the connection electrode unit is configured to be connected to the via hole completely penetrating the upper layer and an electrical signal is transferred to the outside through the via hole, the connection electrode unit is not exposed to the outside, obtaiing the overall compact configuration.

Claims

[Claim 1] A method for fabricating a frequency assembly-type separating apparatus for a cochlear implant, the method comprising:
an upper layer fabrication step of fabricating an upper layer by coating an upper layer electrode unit on a substrate;
a lower layer fabrication step of fabricating a lower layer by including a step of patterning a lower layer electrode unit on a basilar membrane formed on a base and growing a nano-wire having piezoelectric characteristics on the lower layer electrode unit; and
a coupling step of coupling the upper layer and the lower layer such that the upper layer electrode unit and the lower layer electrode unit are electrically connected.

[Claim 2] The method of claim 1, wherein the coupling step comprises:
forming a connection electrode unit electrically connected to the upper layer electrode unit; and a step of coupling the upper layer and the lower layer such that the upper layer electrode unit and the lower layer electrode face each other.

[Claim 3] The method of claim 1, wherein the coupling step further comprises:
forming a via hole to penetrate the substrate; coating an inner surface of the via hole with an electrical conductive material; and forming a connection electrode unit electrically connecting the via hole and the upper layer electrode unit on the substrate.

[Claim 4] The method of claim 2, wherein the forming of the connection electrode comprises:
forming a first connection electrode unit extending from the upper layer electrode unit on the substrate; forming a second connection electrode unit on the base; and forming a third connection electrode unit having one end portion in contact with the first connection electrode unit and the other end portion in contact with the second connection electrode unit.

[Claim 5] The method of any one of claim 1 to claim 4, wherein in patterning the lower electrode unit, a central electrode having a width gradually increased in a length direction of the basilar membrane and an auxiliary electrode extending from the central electrode, which are spaced apart from one another, are patterned.

[Claim 6] The method of claim 5, wherein the lower layer fabrication step further comprising:

removing a portion of the layer provided on a lower surface of the basilar membrane to expose the lower surface of the basilar membrane.

[Claim 7] The method of claim 6, wherein the growing of the nano-wire comprises:
laminating an upper surface of the basilar membrane with a photo-sensitizer; removing a portion of the photosensitizer to expose the central electrode to thereby make the central electrode become a seed layer; and growing a nano-wire by using the central electrode exposed to the outside as a seed layer.

[Claim 8] The method of claim 6, wherein the growing of the nano-wire comprises:
laminating an additional seed layer on on the central electrode; and growing a nano-wire from the seed layer.

[Claim 9] The method of claim 7 or claim 8, wherein the nano-wire is formed by growing a zinc oxide (ZnO) through a low temperature growth method.

[Claim 10] The method of claim 7, further comprising:
coating upper portions of the nano-wire and the basilar membrane with a protective layer in order to prevent damage to the nano-wire after growing the nano-wire.

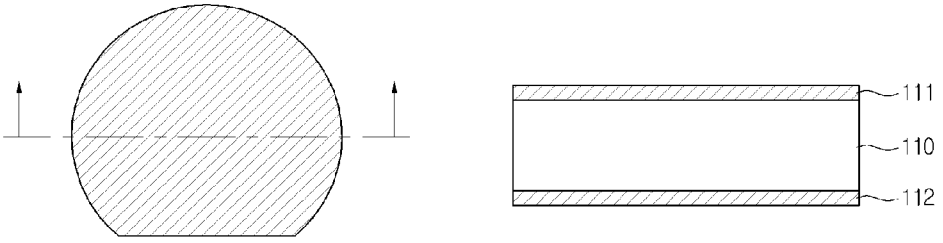
[Claim 11] The method of claim 10, further comprising:
exposing the nano-wire by removing the protective layer coated on an upper portion of the nano-wire, after exposing a lower surface of the basilar membrane.

[Claim 12] The method of any one of claim 1 to claim 4, wherein the upper layer fabrication step comprises:
forming a plurality of first pattern portions formed as the section of the substrate is depressed in a triangular shape, and spaced apart from each other; forming second pattern portions between the neighboring first pattern portions; and coating upper layer electrode units on the first pattern portions and the second pattern portions.

[Claim 13] The method of claim 5, wherein the forming of the second portions comprises:
coating a buffer layer on the substrate between the neighboring first pattern portions; depositing a silicon dioxide ($Si0_2$) layer on an upper portion of the substrate; selectively removing the buffer layer and the silicon oxide layer from the region in which the buffer layer and the silicon dioxide ($Si0_2$) layer are simultaneously formed; etching a substrate region between neighboring silicon dioxide ($Si0_2$) layers to

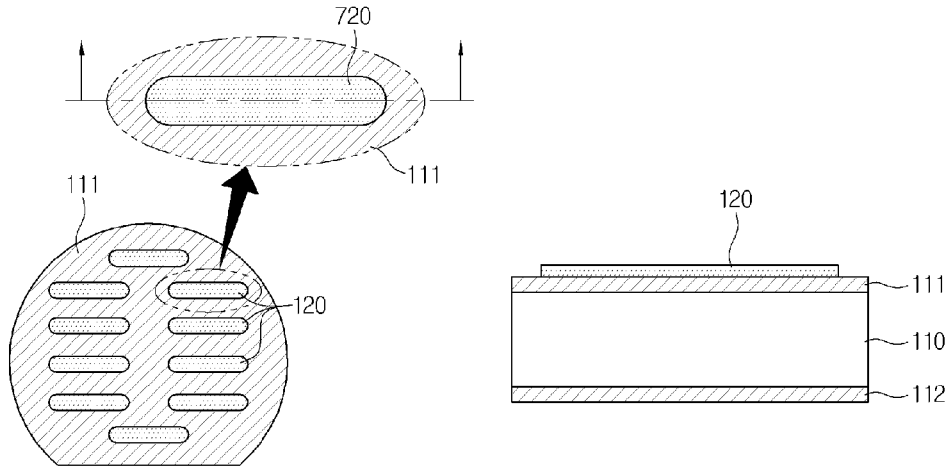
pattern the second pattern portions.

[Fig. 1]



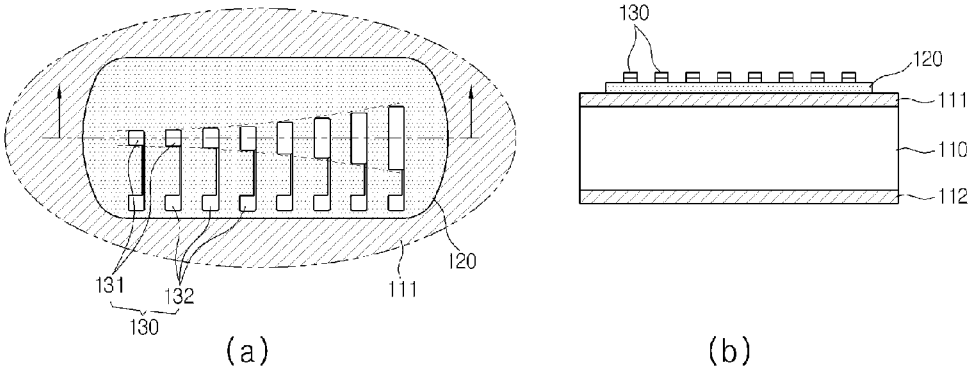
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[Fig. 2]



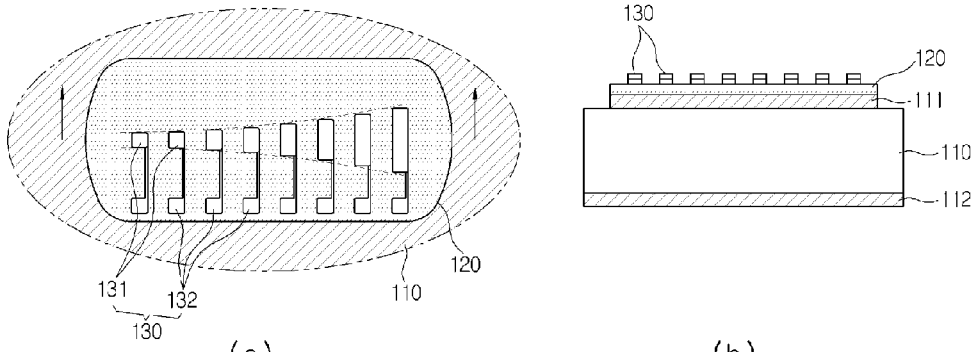
(a) (b)

[Fig. 3]



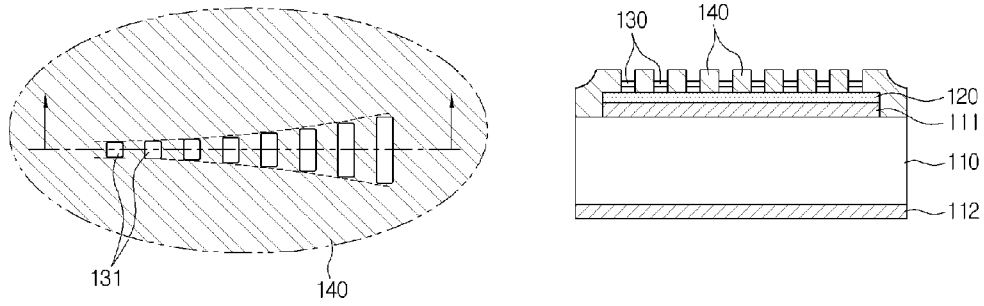
(a) (b)

[Fig. 4]



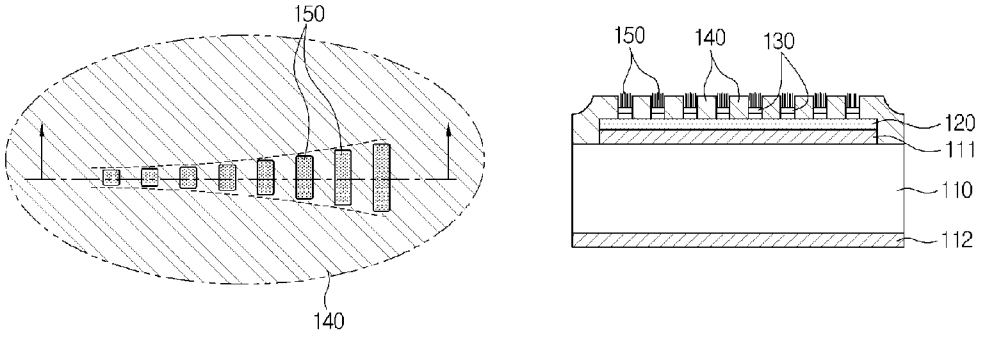
(a) (b)

[Fig. 5]



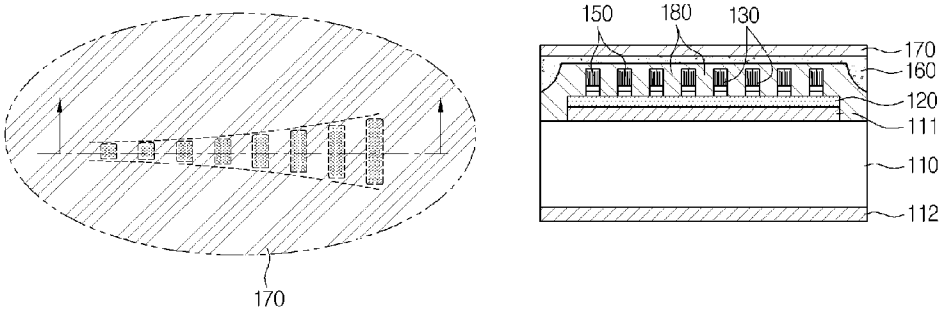
(a) (b)

[Fig. 6]



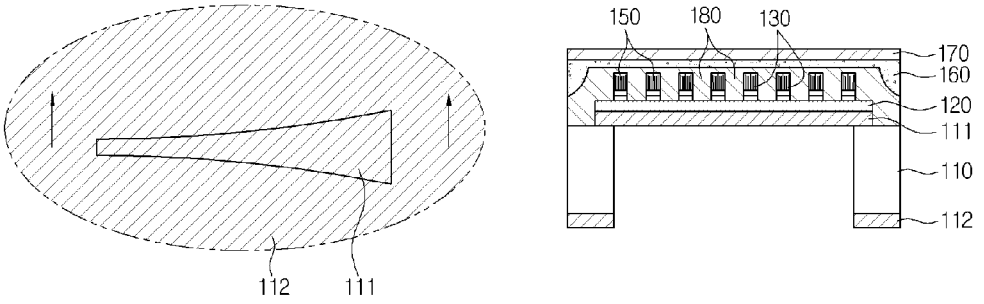
(a) (b)

[Fig. 7]



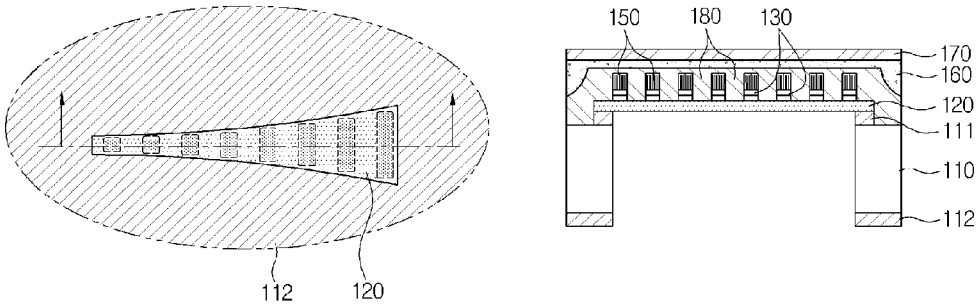
(a) (b)

[Fig. 8]



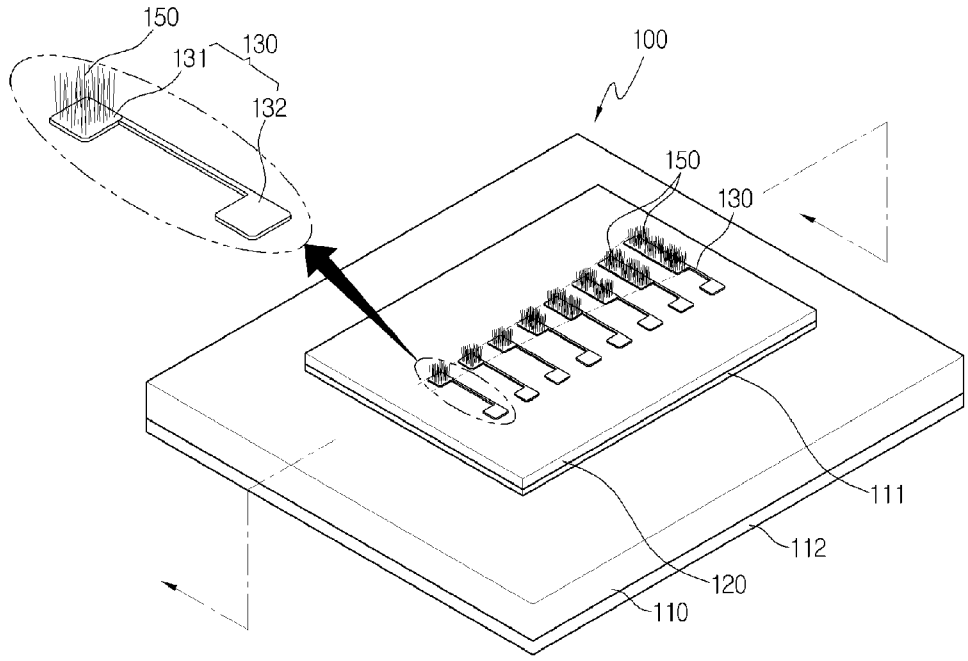
(a) (b)

[Fig. 9]

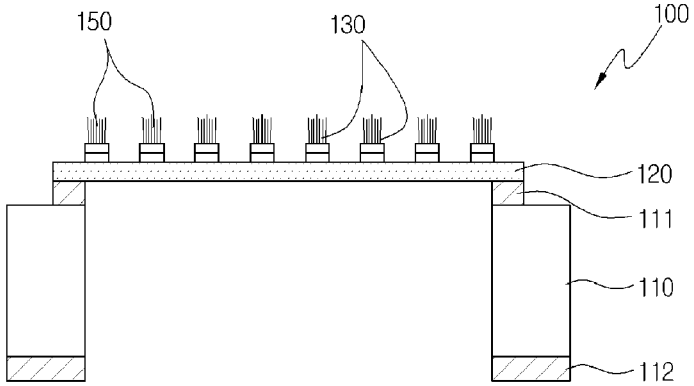


(a) (b)

[Fig. 10]

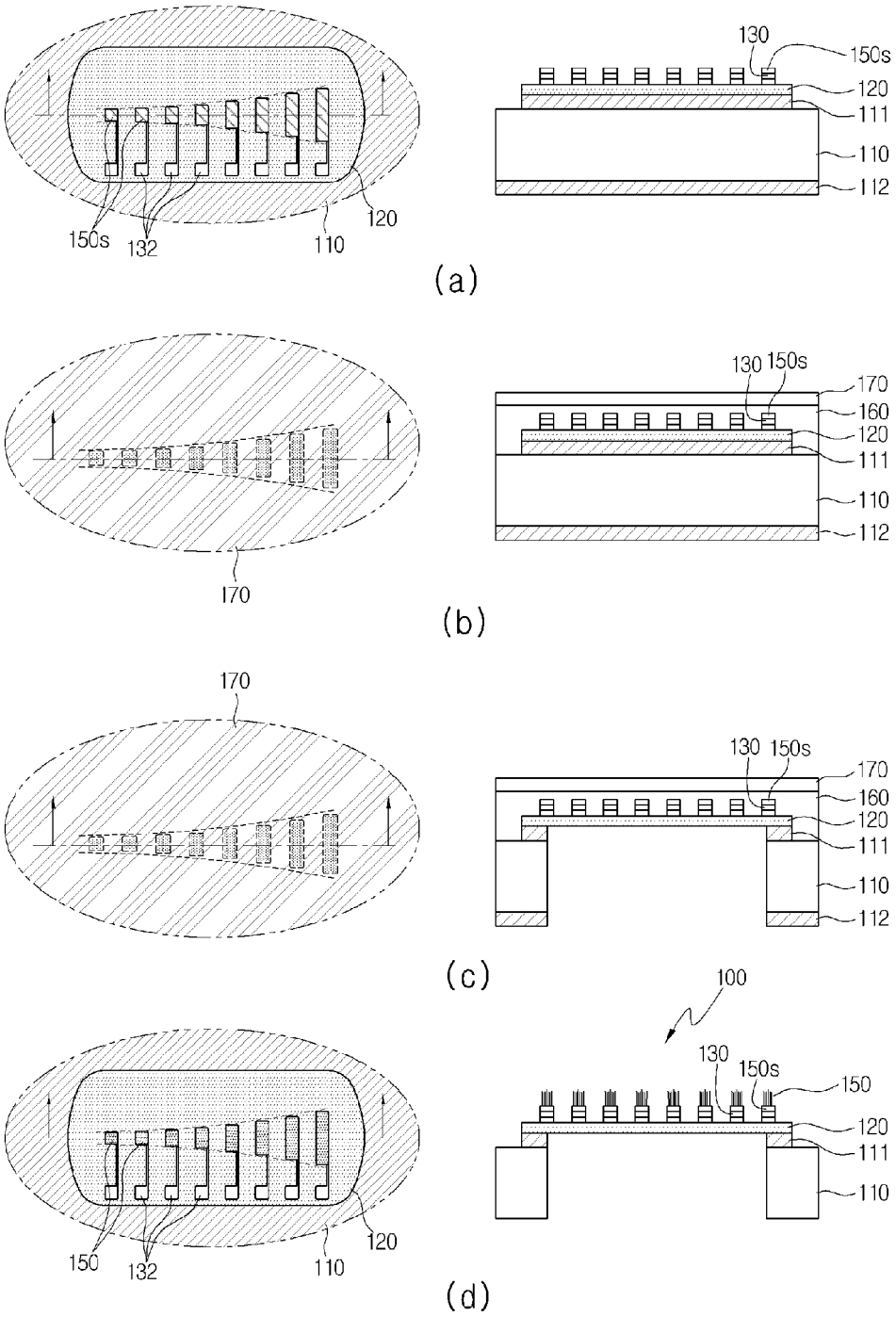


(a)

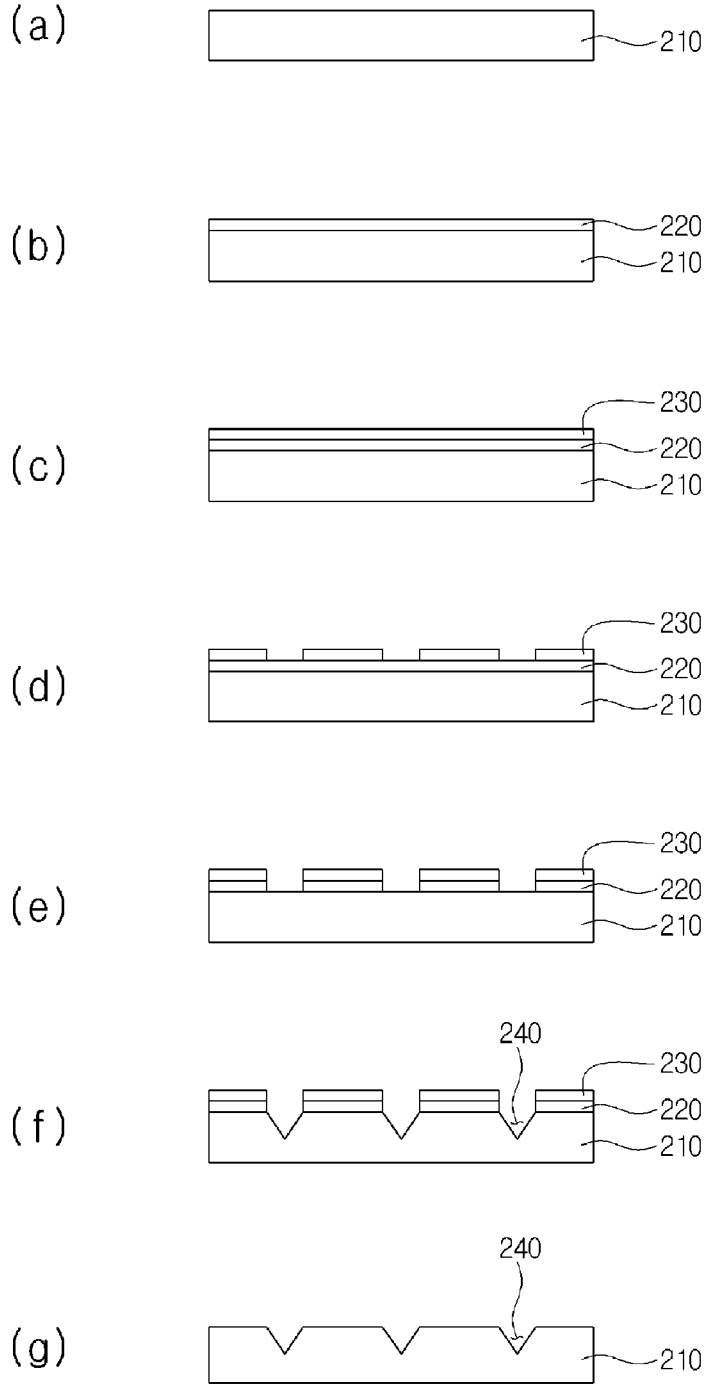


(b)

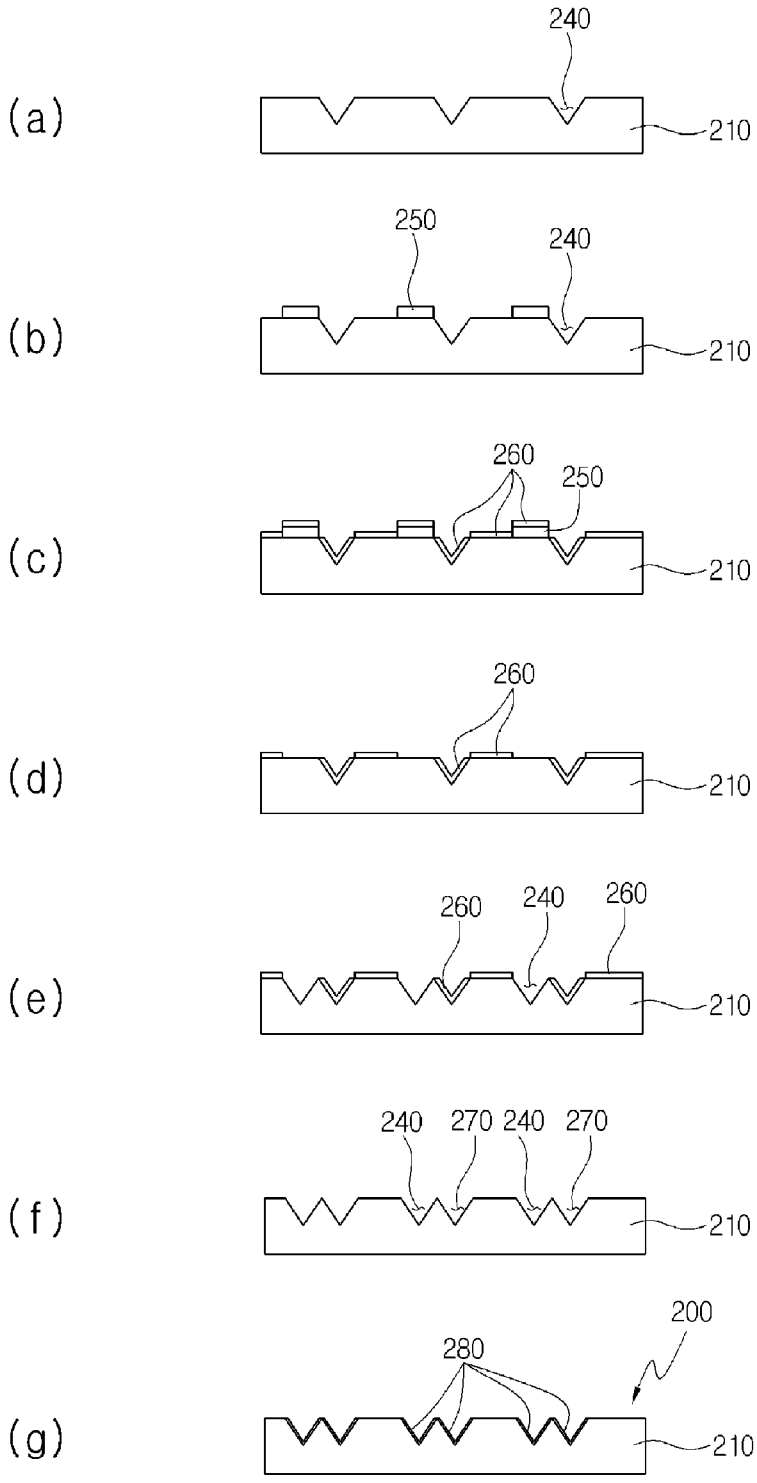
[Fig. 11]


150s
132
110
120
130
150s
120
111
110
112
(a)
170
130
150s
170
160
120
111
110
112
(b)
170
130
150s
170
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(c)
150
132
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120
100
130
150s
150
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111
110
(d)

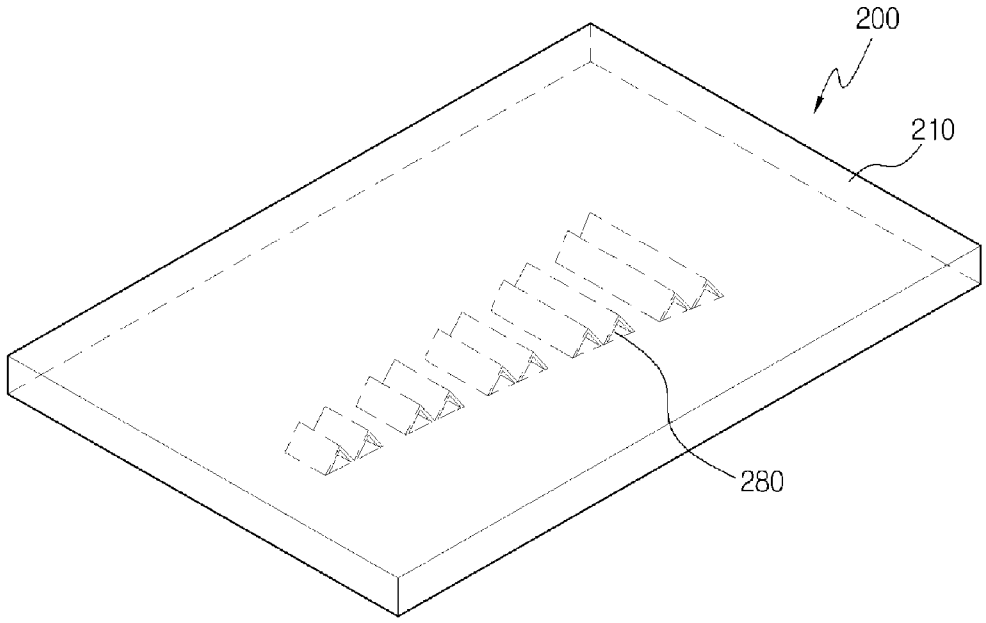
[Fig. 12]


(a)
210
(b)
220
210
(c)
230
220
210
(d)
230
220
210
(e)
230
220
210
(f)
240
230
220
210
(g)
240
210

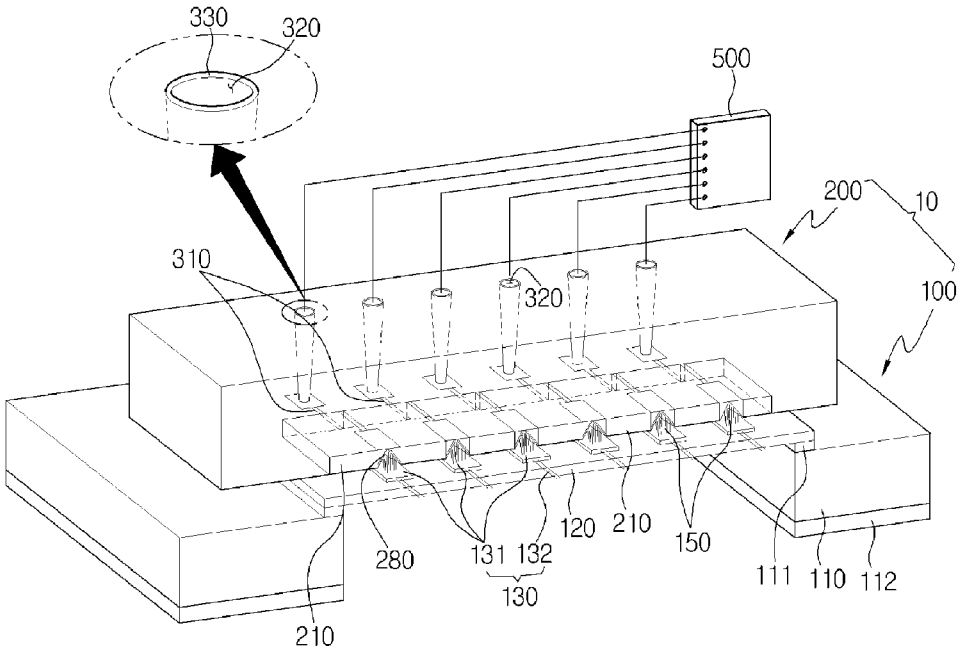
[Fig. 13]


(a)
240
210
(b)
250
240
210
(c)
260
250
210
(d)
260
210
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210
(g)
200
280
210

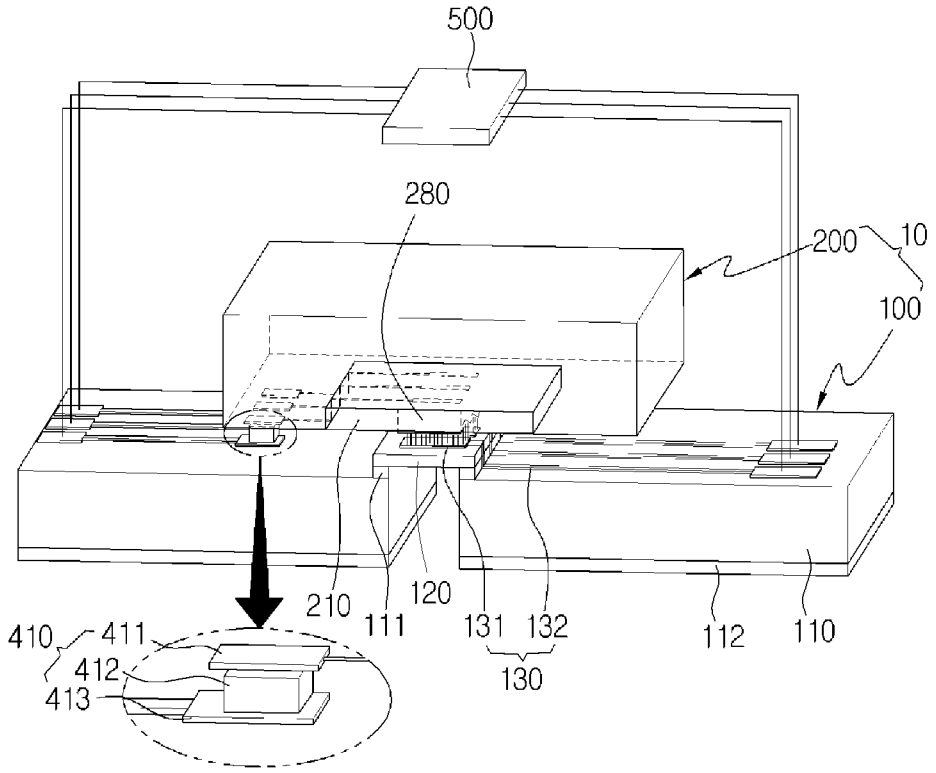
[Fig. 14]


200
210
280

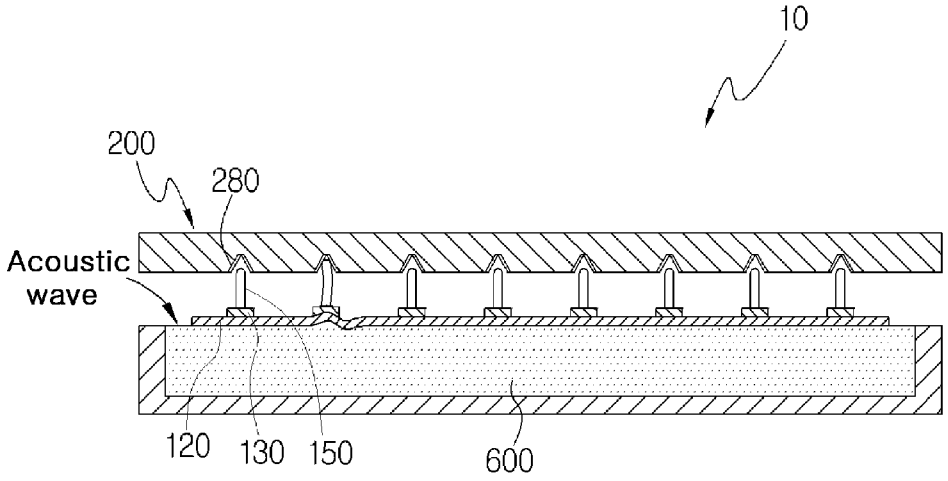
[Fig. 15]


330
320
500
200
10
310
320
100
280
131
132
120
210
150
111
110
112
130
210

[Fig. 16]


500
280
200
10
100
210
111
120
131
132
130
112
110
410
411
412
413

[Fig. 17]


10
200
280
Acoustic
wave
120
130
150
600

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2012/010666

A. CLASSIFICATION OF SUBJECT MATTER

H04R 25/00(2006.01)i, A61F 11/00(2006.01)1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04R 25/00; G01R 23/00; A61F 11/00; B82Y 5/00; H01L 29/40; A61F 2/18; B82Y 30/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: cochlear, electrode, cathod, anode, nanowire, frequency

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	See claim 1 and figures 5a-5b	2-13
A	KR 10-2009-0041892 A (Korea Institude of Machinary & Materials) 29 April 2009 See claim 1 and figure 5a	1-13
A	KR 10-2003-0035758 A (Nurobios is Co., Ltd. et al.) 9 May 2003 See abstract and figure 1	1-13
A	KR 10-1999-0082641 A (Armand P. Neukermans) 25 November 1999 See abstract and figures 1-2	1-13
A	US 6358281 Bl (Peter G. Berrang et al.) 19 March 2002 See abstract and figure 1	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 FEBRUARY 2013 (27.02.2013)	**04 MARCH 2013 (04.03.2013)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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