



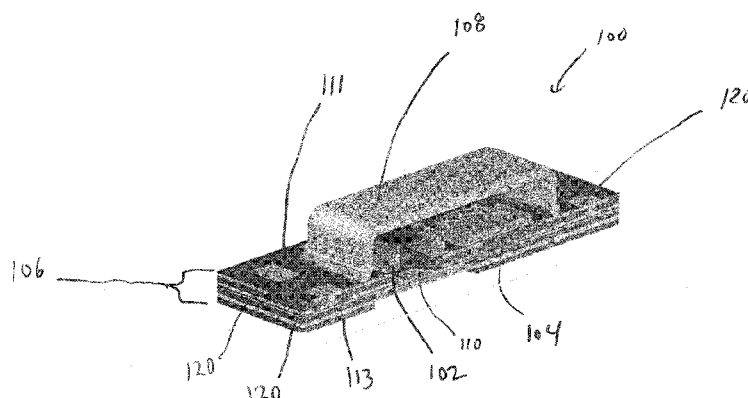
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- with international search report (Art. 21(3))
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(54) **Title:** TOP PORT MICROPHONE APPARATUS**FIG. 1**

(57) **Abstract:** A microphone includes a microphone base that has a first surface and a second surface. The microphone also includes a microelectromechanical system (MEMS) device coupled to the first surface of the microphone base. The microphone also includes a cover coupled to the first surface of the microphone base, such that the cover divides the first surface into a covered portion where the cover encloses the MEMS device, and a non-covered portion extending away from the cover. The microphone also includes one or more pads on the uncovered portion of the first surface of the base. The microphone also includes a port extending through the base from the first surface to the second surface.

TOP PORT MICROPHONE APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This patent claims benefit under 35 U.S.C. §119(e) to United States Provisional Application No. 62/101,643 entitled “Top Port Microphone Apparatus” filed January 9, 2015, the content of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to microelectromechanical system (MEMS) microphones and their configurations.

BACKGROUND OF THE INVENTION

[0003] Microelectromechanical system (MEMS) microphones are used by today's consumers. For example, these microphones may be used in a variety of different customer electronic devices such as cellular phones or personal computers.

[0004] The microphones typically include a MEMS die (with a diaphragm and a back plate). The MEMS die is disposed on a substrate and the substrate is covered by a lid. Sound enters through a hole in the lid or through a hole in the substrate. The sound energy moves the diaphragm. This creates a current which can be further processed by an application specific integrated circuit (ASIC). The processed signal can be made available to electronic devices within the consumer device for further processing.

[0005] The communication path between the ASIC and the external electronic devices is made via the base. More specifically, conductive paths are disposed within the base. The ASIC is coupled to these conductive paths on one side (facing the interior of the microphone) of the base, while other pads are disposed on the other side (facing the exterior of the microphone) of the base. The external electronic devices couple to these pads. Unfortunately, the amount of space on a substrate is limited by the size (foot print)

of the microphone. Consequently, when many pads (or large pads) are used, little space is left for the port opening. As a result, small port openings may have to be used because of the need for large pads on the bottom of the substrate. Small port openings often result in sub-optimal microphone performance.

[0006] These limitations have resulted in some user dissatisfaction with previous approaches.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a more complete understanding of the disclosure, reference should be made to the following detailed description and accompanying drawings wherein:

[0008] FIG. 1 comprises perspective cutaway according to various embodiments of the present invention;

[0009] FIG. 2 comprises top a top view of the microphone of FIG. 1 according to various embodiments of the present invention;

[0010] FIG. 3 comprises a side view of the microphone of FIG. 1 and FIG. 2 according to various embodiments of the present invention;

[0011] FIG. 4 comprises a bottom view of the microphone of FIG. 1, FIG. 2, and FIG. 3 according to various embodiments of the present invention;

[0012] FIG. 5 comprises perspective side view drawing of the microphone of FIG. 1, FIG. 2, FIG. 3, and FIG. 4 as disposed within a customer board according to various embodiments of the present invention;

[0013] FIG. 6 comprises a graph showing some of the advantages of the present approaches according to various embodiments of the present invention.

[0014] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity. It will further be appreciated that certain actions and/or steps may be described or depicted in a particular order of occurrence while those skilled in the

art will understand that such specificity with respect to sequence is not actually required. It will also be understood that the terms and expressions used herein have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein.

DETAILED DESCRIPTION

[0015] In many of these approaches, a top port acoustic device (e.g., microphone) is provided where the external contact pads are on a first surface of the substrate and the port passes through a second and opposite surface of the substrate. The first surface is on one side of the base and the second surface is parallel to the first surface and is on the opposing side of the base. In some aspects, the devices provided herein have a bridge or hat-like configuration. No port passes through the lid when disposed in a customer device.

[0016] With devices so-configured, the size of the port opening can be large because the port opening is not on a surface that couples to the customer electronic board. Put another way, the opening or port of the microphone not couple directly to a customer board or customer electronics. In contrast and in previous approaches, the port coupled directly to or was on a surface that directly coupled to a customer board and this limited the size of the opening that could be used through the base.

[0017] In many of these examples, the microphones provided herein fit within a recess in the customer board. The opening of the microphones provided herein are on the top of the apparatus making the apparatus a top port device.

[0018] Referring now to FIGs. 1-5, one example of a top port microphone that is configured to be placed and used with a customer board is described. The microphone 100 includes a MEMS device 102, an application specific integrated circuit (ASIC) 104, a substrate (or base) 106, a cover (or lid) 108, a port 110, and a barrier 112.

[0019] The MEMS device 102 includes a diaphragm and a back plate. The ASIC 104 processes the electrical signal from the MEMS device.

[0020] The substrate 106 has a first side or surface 111 and a second side or surface 113. The first surface 111 and the second surface 113 are opposite each other on the substrate 106 and do not intersect. The port 110 extends through the substrate 106 between the first surface 111 and the second surface 113, but opens outwardly to the exterior at the second surface 113. Pads 120 are disposed on the first surface 111 of the substrate 106. The pads 120 may provide connections for voltages (e.g., Vdd), clocks (e.g., clk), data, ground (gnd), and selections (sel). Other examples of connections are possible.

[0021] The pads 120 couple to a customer board 122. The customer board 122 may perform any processing function such as a function found in a personal computer or a function that is used in a cellular phone. The cover 108 also couples to the first surface 111. The pads 120 couple to corresponding pads 124 on the customer board 122. The cover fits into a recess or cavity 126 in the customer board 122.

[0022] The cover 108 encloses the MEMS device 102 and the ASIC 104. As mentioned, the cover couples to the first surface 111 of the substrate.

[0023] The port 110 allows sound energy to pass from the exterior of the microphone to the interior of the microphone. The barrier 112 keeps debris from entering the interior of the microphone, specifically the MEMs diaphragm. In one aspect, the barrier 112 may be a membrane containing pores. The pore size can be modified to tune the acoustic resistance of the audio path to the MEMs device. In one aspect, pores in the membrane may compromise protection against debris making their use appropriate for applications where modification to acoustic response is critical.

[0024] In one example of the operation of the system of FIG. 1, sound energy passes into the port 110. The sound energy moves the diaphragm on MEMS device 102, which creates a voltage or current. The voltage or current is transmitted to the ASIC 106, which further processes the signal. The processed signal is send through the substrate 106 to the pads 120. The pads 120 couple to pads 124 of consumer board 122. The consumer board 122 further processes the signal.

[0025] It will be appreciated that the size of the port 110 can be large, for example greater than 1 millimeter in diameter, because the port 110 is not on a surface that directly couples to the customer electronic board. In these regards, the second surface 113 does not directly couple to the customer board 122. When disposed together with customer board 122. The opening of the port is disposed on the top of the apparatus (making the apparatus a top port device) even though the port does not extend through the lid 108. Since the port 110 is disposed through second surface 113 that does not include any of the pads 120, the port 110 can practically be any size (within the dimensions of the microphone) but in general port diameters less than 1 millimeter should be avoided to minimize degradation to microphone electroacoustic response. Microphones with smaller height dimensions are also provided.

[0026] Referring now to FIG. 6, one example of some of the advantages of the present approaches are described. The graph shows signal to noise ratio degradation (in dB) on the Y-axis and port or mesh opening diameter on the X-axis. As the port opening size increases, it can be seen that the signal to noise ratio (SNR) degradation decreases. The present approaches in one example provide performance in the bottom right region of the graph of FIG. 6.

[0027] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. It should be understood that the illustrated embodiments are exemplary only, and should not be taken as limiting the scope of the invention.

WHAT IS CLAIMED IS:

1. A microphone, comprising;

a microphone base, the microphone base having a first surface and a second surface;

a microelectromechanical system (MEMS) device coupled to the first surface of the microphone base;

a cover coupled to the first surface of the microphone base, such that the cover divides the first surface into a covered portion where the cover encloses the MEMS device, and a non-covered portion extending away from the cover;

one or more pads on the uncovered portion of the first surface of the base; and

a sound port extending through the base from the first surface to the second surface.
2. The microphone of claim 1, further comprising an integrated circuit disposed on the covered portion of the first surface.
3. The microphone of claim 1, wherein the first surface and the second surface are parallel and do not intersect.
4. The microphone of claim 1, wherein the second surface remains uncoupled to a customer device.
5. The microphone of claim 1, wherein the one or more pads is coupled to a customer device.
6. The microphone of claim 1, further comprising a barrier over the sound port.
7. The microphone of claim 1, wherein the sound port has a diameter greater than 1 mm.
8. The microphone of claim 1, wherein the microphone is disposed within a customer device such that the device is disposed as a top port device within the customer

device.

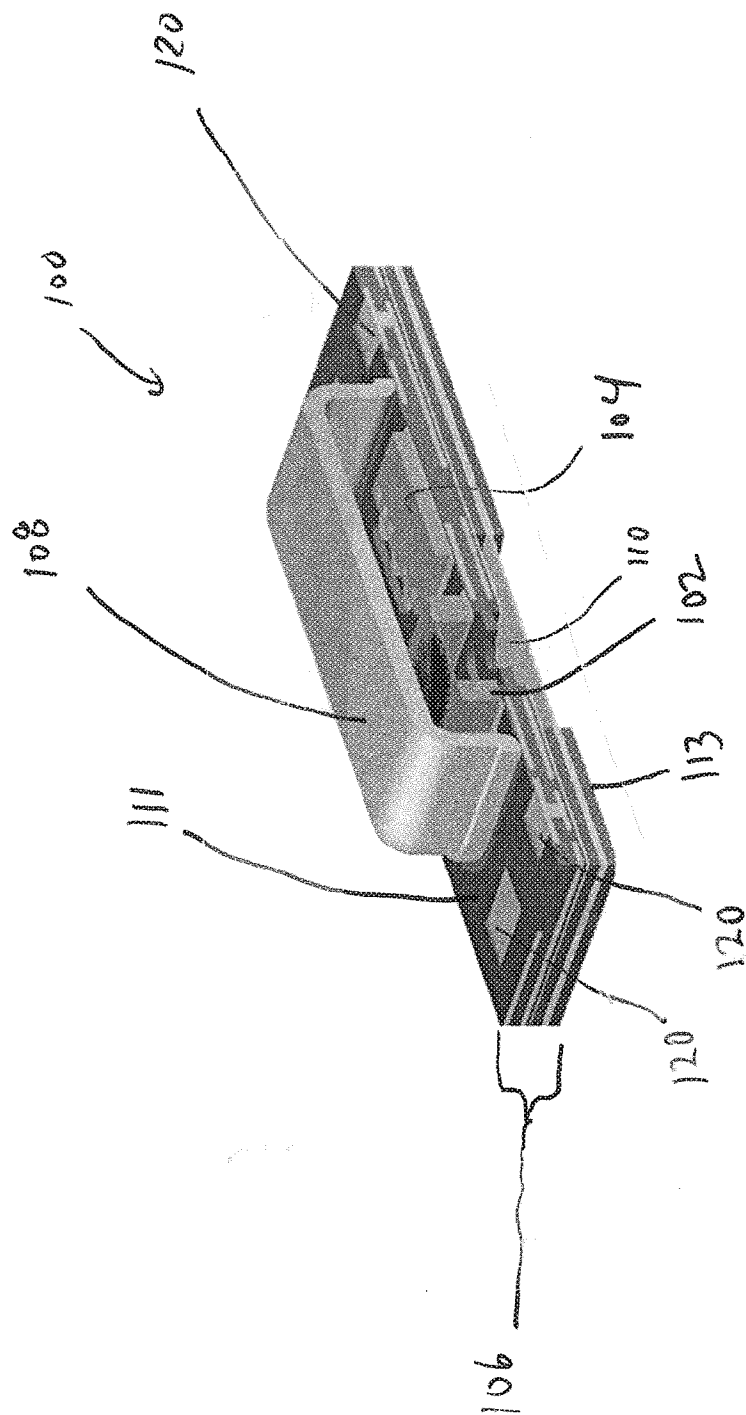


FIG. 1

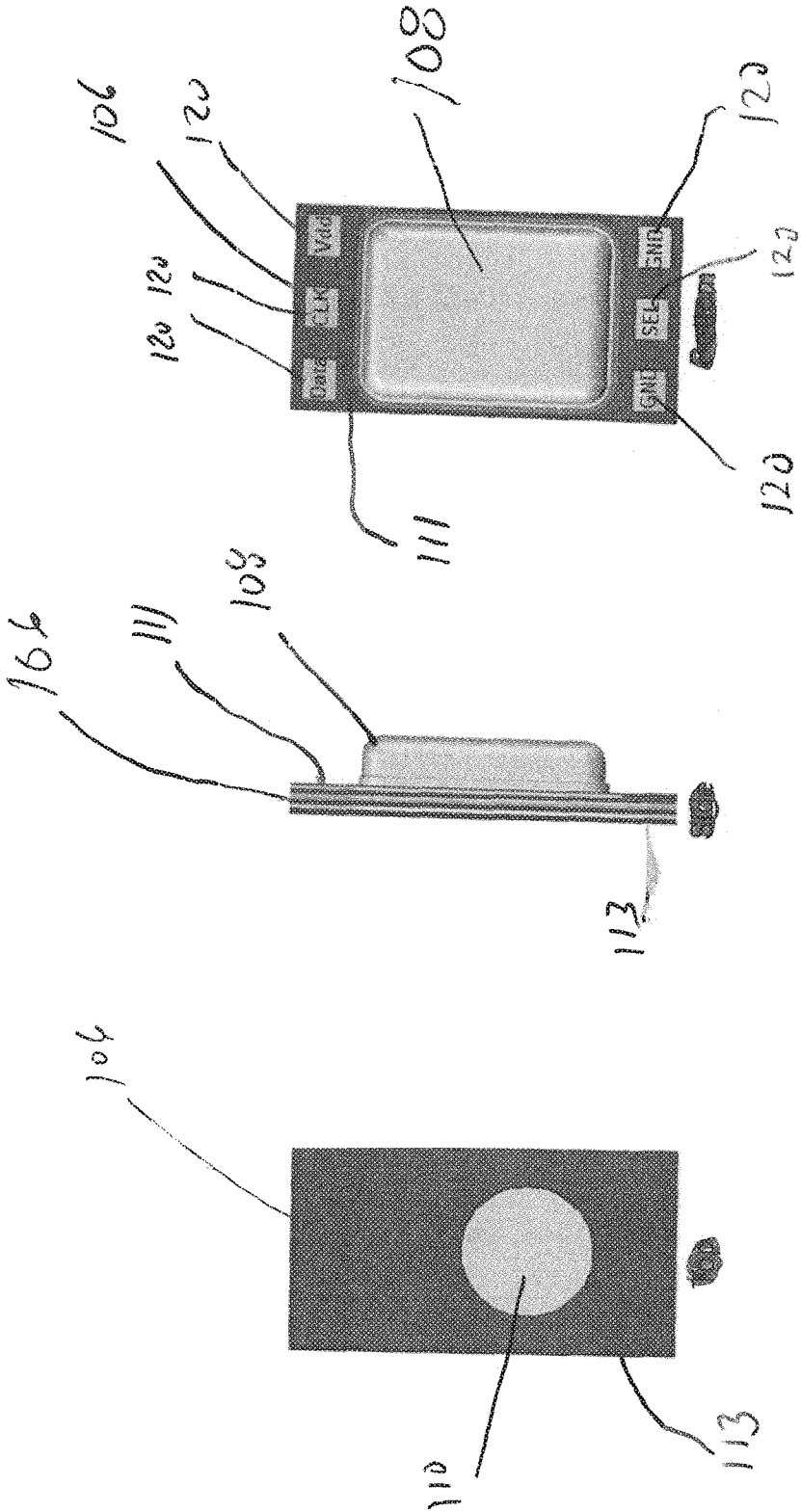
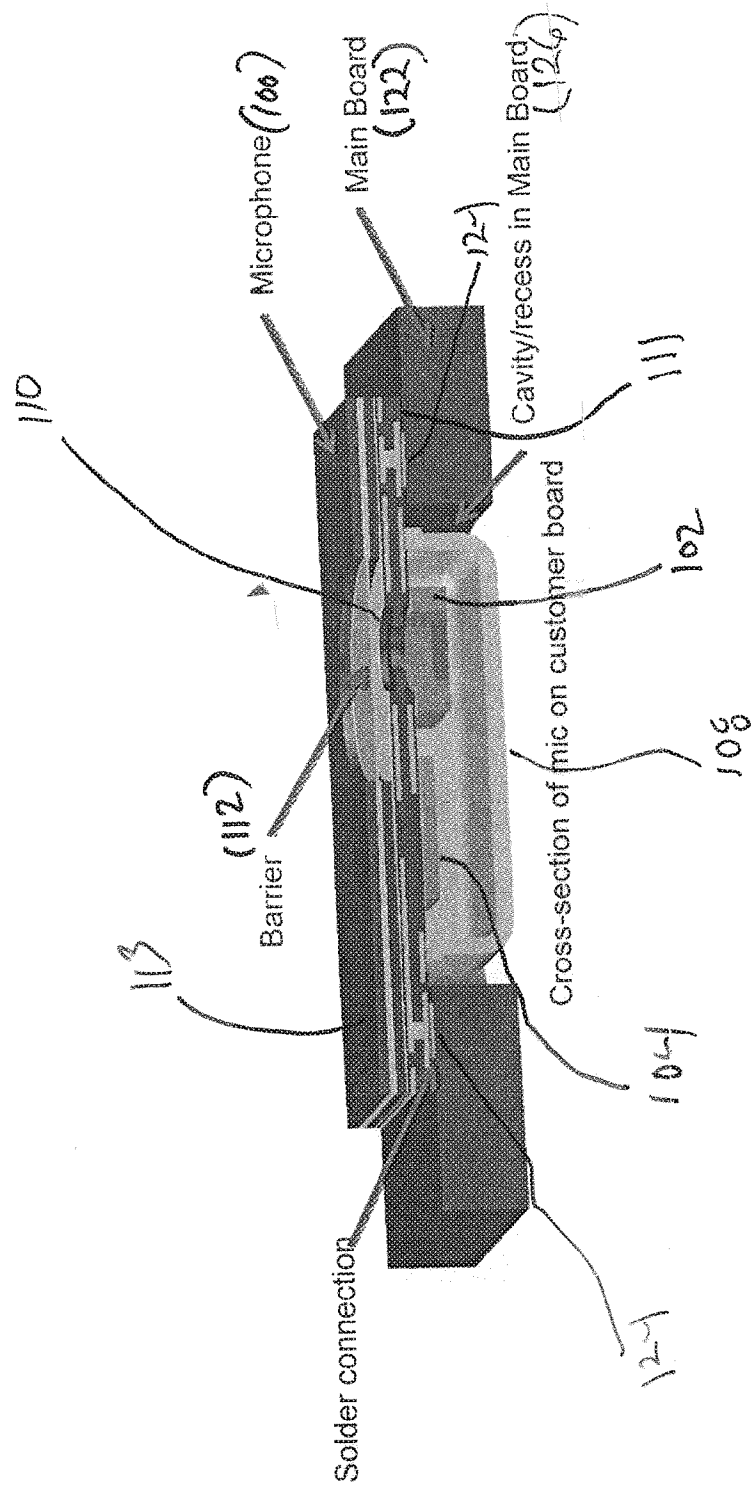


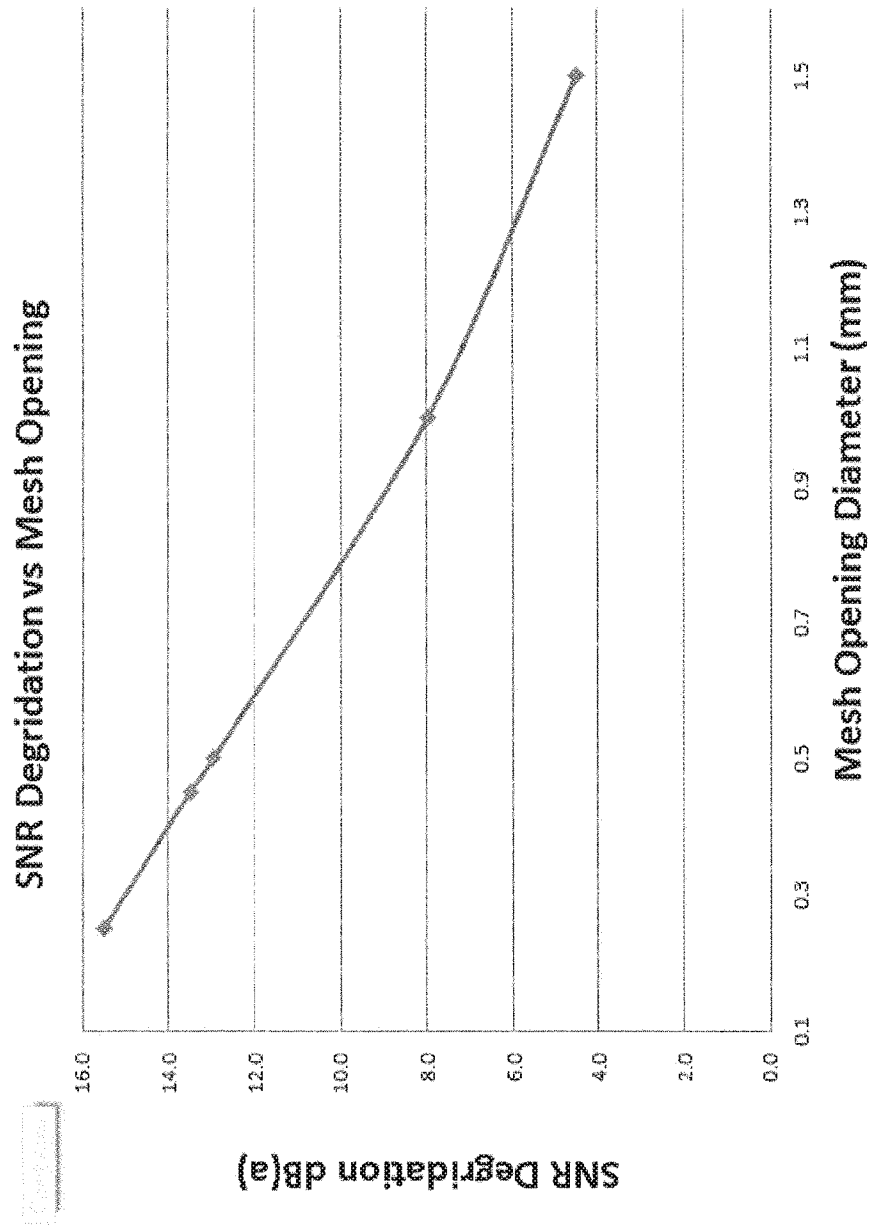
FIG. 4

FIG. 3

FIG. 2



F16.5



F16.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/067385**A. CLASSIFICATION OF SUBJECT MATTER****H04R 19/04(2006.01)i, B81B 3/00(2006.01)i**

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 19/04; H01L 29/84; H04R 1/08; B81B 3/00; H01L 21/02; B81C 1/00

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: microphone, base, microelectromechanical system (MEMS), cover, covered portion, non-covered portion, pad, sound port

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0294221 A1 (KIERAN P. HARNEY et al.) 02 October 2014 See abstract, paragraphs [0052]-[0061], [0101]-[0104], claim 1 and figures 4A-4B, 27.	1-8
A	US 2014-0248730 A1 (TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY, LTD.) 04 September 2014 See paragraphs [0031]-[0035] and figures 9, 12.	1-8
A	US 2014-0217521 A1 (ANALOG DEVICES, INC.) 07 August 2014 See paragraphs [0029]-[0035], claim 1 and figures 2A-2B.	1-8
A	US 2011-0165717 A1 (CHIEN-HSING LEE et al.) 07 July 2011 See paragraph [0045] and figure 14.	1-8
A	US 2010-0155864 A1 (RICHARD I. LAMING et al.) 24 June 2010 See paragraphs [0027]-[0029], claim 48 and figure 2.	1-8

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

* Special categories of cited documents:

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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International Application Division

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189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

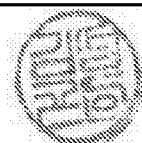


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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/067385

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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		WO 2007-107736 A2	27/09/2007
		WO 2007-107736 A3	11/09/2009