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Integrated interconnect for a back-firing microphone circuit board

Abstract

A circuit board assembly includes a top circuit board forming a microphone aperture and carrying electrical conductors. The circuit board assembly further includes a back-firing microphone connected to the top circuit board, the circuit board assembly providing support for the microphone, and the microphone electrically connected to the electrical conductors. The circuit board assembly further includes at least one interposer connected to the circuit board assembly, the at least one interposer positioned to the side of the back-firing microphone and including vias for providing a pathway for electrical connection to the top circuit board conductors.

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Background/Summary

BACKGROUND

(1) A microphone mounted to a circuit board may be a top-firing microphone or a back-firing microphone. Top-firing and bottom-firing microphones each have advantages and disadvantages, but back-firing microphones, which are more challenging to accommodate mounting, have an acoustic advantage over top-firing microphones and are often selected for use in mobile devices such as smartphones, tablets, laptops, home speakers, and other products.

(2) The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

SUMMARY

(3) In some embodiments, a circuit board assembly comprises a top circuit board forming a microphone aperture and carrying electrical conductors. The circuit board assembly further

includes a back-firing microphone connected to the top circuit board, the circuit board assembly providing support for the microphone, and the microphone electrically connected to the electrical conductors. The circuit board assembly further includes at least one interposer connected to the circuit board assembly, the at least one interposer positioned to a side of the back-firing microphone and including vias for providing a pathway for electrical connection to the top circuit board conductors.

(4) In some embodiments, the circuit board assembly further including a bottom circuit board, the bottom circuit board forming an opening for the microphone, the at least one interposer physically connecting the top and bottom circuit boards and providing multiple electrical connections. In some embodiments, the top circuit board includes a stainless-steel stiffener, a charge transfer sense amplifier, and a flexible board. In some embodiments, the top circuit board is a flexible circuit board. In some embodiments, the top circuit board is a rigid board. In some embodiments, the circuit board assembly further includes a bottom circuit board, the bottom circuit board supporting other components and including electrical conductors, the vias providing an electrical connection between the top circuit board conductors and the bottom circuit board conductors. In some embodiments, the at least one interposer is an interposer extending at least partially around the microphone. In some embodiments, the at least one interposer includes two or more interposers, the interposers positioned on different sides of the microphone.

(5) In some embodiments, the bottom circuit board is a two-layer flex with a stack that includes a first layer of copper, a second layer of polyimide, and a third layer of copper, wherein the second layer of polyimide is in between the first layer and the third layer. In some embodiments, the at least one interposer includes at least one interposer with four or more vias. In some embodiments, the at least one interposer includes at least one interposer with five vias that are arranged in a sawtooth pattern. In some embodiments, the circuit board assembly further comprises filtering and electrical components connected to top circuit board. In some embodiments, the bottom board is a two-layer flex with a stack that includes a first layer of copper, a second layer of polyimide, and a third layer of copper, wherein the second layer of polyimide is in between the first layer and the third layer. In some embodiments, the bottom board includes traces, a width of the traces is 50 μm, and a space between the traces is about 75 μm.

(6) The specification advantageously identifies a back-firing microphone design that optimizes for x- and y-real estate, while taking advantage of the space in z-space rather than growing the circuit board. Additionally, the technology relies on the attachment strength of soldering to hold the separate board in place, rather than a small surface area of a pressure sensitive adhesive, which can have reliability concerns. Lastly, the increased surface area provides more support for wetting out a separate mesh part for ingress protection and acoustic performance.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** illustrates a perspective view of an example mobile device, according to some embodiments described herein.

(2) FIG. **2** is a diagram illustrating an example prior art circuit board.

(3) FIGS. **3**A-**3**C are diagrams of an example circuit board assembly with a back-firing microphone, according to some embodiments described herein.

(4) FIG. **4**A-**4**C are diagrams of another example of a circuit board assembly with a back-firing microphone, according to some embodiments described herein.

(5) FIGS. **5**A-**5**D are diagrams of the bottom board, the top board, and interposers, according to some embodiments described herein.

DETAILED DESCRIPTION

(6) FIG. **1** a perspective view of an example mobile device **100**. A mobile device **100** may include one or more microphone ports. In this example, the mobile device **100** includes a visor **110** that includes one example of a microphone port **120**. The microphone port **120** may be located on any part of the visor **110** as well as any part of the mobile device **100**.
(7) The surface area on circuit boards for a microphone may be limited in different devices. Furthermore, the back-firing microphone can only be assembled on a specific side of the circuit board. FIG. **2** illustrates a diagram **200** of an example prior art circuit board. The circuit board includes a back-firing microphone **205** that is below two interposers **210***a*, **210***b*, and held in place with a flex tail **215** with a 280-degree bend (seen on the right-hand side of the figure). The flex tail **215** artificially increases x- and y-real estate while ensuring that the back-firing microphone is placed in the correct orientation. The flex tail **215** is kept in place with adhesive. When exposed to high temperature and/or high humidity, the adhesive as well as the tension in the 180-degree bend can fail, e.g., can delaminate.
(8) FIG. **3**A-**3**C are diagrams of an example circuit board assembly with a back-firing microphone.
(9) FIG. **3**A illustrates a plan view of a circuit board assembly **300**. The circuit board assembly **300** includes a circuit board **302**. For example, circuit board **302** may be a printed circuit board. In some embodiments, circuit board **302** is a flexible circuit board. The circuit board assembly **300** further includes an interposer **305**, a microphone **310**, and filtering and electrical components **315**. In some embodiments, the electrical components **315** may be omitted.
(10) In this example, as seen in FIG. **3**A, the interposer **305** is a single U-shaped component that surrounds (partially circumscribes) the microphone **310**. The interposer **305** is a physical support that includes conductors for routing signals between the circuit board **302** and other circuitry not carried on circuit board **302**. The interposer provides the mechanical standoff between the circuit board **302** and an adjacent connected board. The interposer may be formed from a printed circuit board stock cut to the desired shape. In some embodiments, the single interposer **305** is preferable to using multiple interposers because the single interposer **305** is more stable and includes less variation during soldering than would occur if multiple interposers are used. In some embodiments, the width of the interposer **305** is between 5 and 6 mm and the height is between 3.5 and 5 mm, the width between the portion of the interposer **305** on the right side of the microphone **310** is between 1 and 2 mm, and the height of the portions of the interposer **305** that are above and below the microphone **310** in FIG. **3**A are between 1 and 2 mm.
(11) The electrical components **315** provide filtering and electrical bypassing for signals. In this embodiment, the electrical components **315** are grouped together such that the interposer **305** and the microphone **310** set the size of the microphone assembly by being allocated for most of the lateral space on the circuit board **302**.
(12) FIG. **3**B is a diagram illustrating side view of a microphone assembly **325** for a flexible circuit board according to some embodiments. The microphone assembly **325** includes a top board **330** and a bottom board **335**.
(13) The top board **330** includes a flexible board (e.g., a mini-flex) that is composed of a stainless-steel stiffener **340** (which in some embodiments is about 0.15 mm), a charge transfer sense amplifier **345** that in some embodiments is about 0.04 mm thick, and a flex substance **350** that in some embodiments is about 0.12 mm thick. The stiffener **340** functions as a mechanical support but may also provide heat dissipation. The stiffener **340** may be bonded on one or two sides with adhesive, polyethylene, or pressure sensitive adhesive tape. The charge transfer sense amplifier **345** enables the electric audio signals generated by the back-firing microphone **365** to be transmitted to a processor (not illustrated).
(14) The top board **330** forms a microphone aperture **355**. Although the microphone aperture **355** is illustrated as having the same aperture width for each of the three levels of the top board **330**, different widths are possible.
(15) In some embodiments, the top board **330** includes an acoustic mesh (not illustrated) that

provides water sealing and protection against foreign objects entering the microphone aperture **355**. The stainless-steel stiffener **340** in the top board **330** is a rigid material that allows compression of the acoustic mesh.

(16) In between the top board **330** and the bottom board **335** are an interposer **360** and a back-firing microphone **365**. In some embodiments, the interposer **360** may be soldered onto (or otherwise mounted on) the top board **330**. The interposer **360** is illustrated from the side, and can be a single interposer, like interposer **305** in FIG. **3**A, or multiple interposers on different (or opposite) sides of the back-firing microphone **365**, like the interposers illustrated in FIGS. **4**A-**4**C. The back-firing microphone **365** includes a hole **362** for reception of audio, the hole aligned with the microphone aperture **355**. In some embodiments, the interposer has a height of approximately 1 mm. Signals are routed through the interposer **360**. The back-firing microphone **365** may be connected to an application-specific integrated circuit (ASIC) or other suitable processor (not illustrated).

(17) The back-firing microphone **365** is mounted onto one surface of the top board **330** using surface-mount technology, such as soldering. In some embodiments, the back-firing microphone **365** is radio frequency shielded to isolate the back-firing microphone **365** from electromagnetic interference. In some embodiments, a cover (not shown) that surrounds the back-firing microphone **365** shields the back-firing microphone **365** from electromagnetic interferences.

(18) In some embodiments, the bottom board **335** is a flexible board. In some embodiments, the bottom board **332** includes a two-layer flexible board with a copper/polyimide/copper stack where the thickness of the layers is about 10.8 μm/25 μm/10.8 μm. The bottom board **335** forms a cutout for the back-firing microphone **365** that is discussed in greater detail below.

(19) The bottom board **335** is designed with a layout that prevents electrostatic discharge. The signal traces, power traces, and ground traces are separated by a non-conductive material, such as a dielectric polymer (not illustrated). The bottom board **335** includes traces that are each formed by a thin conductive foil patterned onto a dielectric substrate. Each trace is patterned onto the dielectric substrate in a designed circuit pattern using, for example, photolithography and etching techniques. The conductive foil may be copper, although other conductive materials may be used. In some embodiments, the width of the traces is about 50 μm and the space between the traces is about 75 μm.

(20) The bottom board **335** also includes vias, which are interconnecting nodes between different layers of the circuit board. The area between a hole drilled into a via and an edge of the conductive copper pad is referred to as an annular ring. In some embodiments, the diameter of the hole in the bottom board **335** is 100 μm and the diameter of the annular ring in the bottom board **335** is 300 μm.

(21) In some embodiments, the top board **330** and the bottom board **335** are both flexible boards. For example, the top board **330** and the bottom board **335** can be panelized in parallel to reduce the cost and complexity of producing the flexible circuit board.

(22) FIG. **3**C is a diagram illustrating printed circuit board **375** according to some embodiments. The printed circuit board **375** includes a rigid board for a top board **380** instead of the mini flex that is part of a flexible circuit board because the printed circuit board **375** is a less flexible embodiment. The top board **380** may be a 0.3 millimeter (mm) thick rigid board.

(23) FIG. **4**A illustrates a plan view of a flexible circuit board or a printed circuit board. The circuit board **400** includes interposers **405***a*, **405***b*, a microphone **410**, and filtering and electrical components **415***a, b, c*. In FIG. **4** and the other figures, a letter after a reference number, e.g., "**405***a*," represents a reference to the element having that particular reference number. A reference number in the text without a following letter, e.g., "**405**," represents a general reference to embodiments of the element bearing that reference number.

(24) In this example, the filtering and electrical components **415** are grouped as filtering and electrical components **415***a, b* on one side of the microphone **410** and filtering and electrical components **415***c* on the other side of the microphone **410**. Because the interposers **405** take up less

surface area than in the embodiment illustrated in FIG. **3**A, a greater number of configurations of the filtering and electrical components **415** is possible.
(25) FIG. **4**B is a diagram illustrating side view of a printed circuit board **425** according to some embodiments. The printed circuit board **425** is designed with a top board **430** and a bottom board **435**.
(26) FIG. **4**C is a diagram illustrating a printed circuit board **450** according to some embodiments.
(27) FIGS. **5**A-**5**D are diagrams of the bottom board, the top board, and the interposers.
(28) FIG. **5**A illustrates a plan view of a bottom board **500**, according to some embodiments. The bottom board **500** is a flexible board that forms a cutout in the center of the bottom board **500** for the microphone. In this example, the bottom board **500** sits on top of two interposers **505***a*, **505***b*. In some embodiments, the two interposers **505***a*, **505***b* may be a single interposer as illustrated in FIGS. **3**A-**3**C. The bottom board **500** also includes conductive lines to carry speaker and microphone signals **510**.
(29) FIG. **5**B illustrates a plan view of the top board **525**, according to some embodiments. In FIG. **5**B, a board outline **527**, an outline of the interposer **530***a*, *b*, an example of conductive lines for a signal **535** that is routed through the interposer, an example of conductive lines to carry discrete signal **540** for the microphone, and the stiffener **545** are illustrated.
(30) The top board **525** includes copper layers to create a ground shield for preventing electrostatic discharge on the microphone porting hole sides of the top board **525** to reduce the risk of damage as compared to the flex-tail design illustrated in the prior art assembly of FIG. **2**.
(31) FIG. **5**C is a diagram illustrating a middle standoff first interposer **550**, according to some embodiments. The interposer **550** may be a two-layer rigid board with four, five, or more vias for connectivity for signals that provide power, a clock, data, and one or two ground signals. In some embodiments, a microphone needs at least four signal connections to function. In some embodiments, a single interposer model needs at least four vias, but would likely have many more to provide better mechanical strength and signal redundancy.
(32) In this example, FIG. **5**C illustrates five vias where the fifth via may provide redundancy for either the power, clock, data, or ground signals, and three mechanical vias that do not provide electrical connection, but add to the strength of the overall solder joints between the interposer **550** and boards. In some embodiments, the first interposer **550** may have a thickness of 1.07 mm with a minimum x/y of 1.6 mm/1.25 mm. In some embodiments, the diameter of the hole in the via in the first interposer **550** may be 0.25 mm and the diameter of the of the annular ring may be 0.1 mm as illustrated in FIG. **5**C. The distance between the centers of the vias may be 0.35 mm for the eight vias illustrated in FIG. **5**C.
(33) FIG. **5**D is a diagram illustrating a middle standoff second interposer **575**, according to some embodiments. The diameter of the hole of the via in the second interposer **575** is illustrated as 0.2 mm and the diameter of the annular ring of the via in the second interposer **575** is illustrated as 0.4 mm. The distance between the centers of the vias may be 0.5 mm for the four vias as illustrated in FIG. **5**D. In some embodiments, through hole type vias are not used for mobile phones because they may be too large to fit, but if they are used the cost of producing a printed circuit board may be cheaper than otherwise.
(34) In some embodiments, the vias may be organized as a sawtooth pattern such as shown in FIG. **5**D. Extra mechanical vias may be added to the board edge to create greater mechanical strength. In some embodiments, the size of the interposer **550**, **575** may be achieved using a high-density interconnect circuit board where the annular ring is between about 0.1 mm to 0.25 mm.
(35) FIG. **5**C and FIG. **5**D show two alternative via layouts with the same sized layout outline, but with different vias. FIG. **5**D uses a larger “through hole” type via technology (drill/annular ring of 0.2 mm/0.4 m). It has four vias, which is the minimum number of signal connections the microphone needs to function, but most designs would likely have many more vias to provide better mechanical strength and signal redundancy. FIG. **5**C uses smaller “HDI (1+2+1)” type via

technology (drill/annular ring of 0.1 mm/0.25 mm). Because there is extra room on this layout, three of the vias on the back row are marked with an “X” to signify that they would be mechanical only and don't provide any electrical connection.
(36) In the above description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the specification. It will be apparent, however, to one skilled in the art that the disclosure can be practiced without these specific details. In some instances, structures and devices are shown in diagram form in order to avoid obscuring the description. For example, the embodiments can be described above primarily with reference to particular hardware. However, the embodiments can apply to any type of circuit board.
(37) Reference in the specification to “some embodiments” or “some instances” means that a particular feature, structure, or characteristic described in connection with the embodiments or instances can be included in at least one implementation of the description. The appearances of the phrase “in some embodiments” in various places in the specification are not necessarily all referring to the same embodiments.

Claims

1. A circuit board assembly comprising: a top circuit board forming a microphone aperture and carrying electrical conductors; a back-firing microphone connected to the top circuit board, the circuit board assembly providing support for the microphone, and the microphone electrically connected to the electrical conductors, wherein a top of the back-firing microphone is connected to a bottom of the top circuit board; and at least one interposer connected to the circuit board assembly, the at least one interposer positioned to a side of the back-firing microphone and including vias for providing a pathway for electrical connection to the electrical conductors in the top circuit board.
2. The circuit board assembly of claim 1, the circuit board assembly further including a bottom circuit board, the bottom circuit board forming an opening for the microphone, the at least one interposer physically connecting the top and bottom circuit boards and providing multiple electrical connections.
3. The circuit board assembly of claim 1, wherein the top circuit board includes a stainless-steel stiffener, a charge transfer sense amplifier, and a flexible board.
4. The circuit board assembly of claim 1, wherein the top circuit board is a flexible circuit board.
5. The circuit board assembly of claim 1, wherein the top circuit board is a rigid board.
6. The circuit board assembly of claim 1, further including a bottom circuit board, the bottom circuit board supporting other components and including electrical conductors, the vias providing an electrical connection between the electrical conductors in the top circuit board and the electrical conductors in the bottom circuit board.
7. The circuit board assembly of claim 1, wherein the at least one interposer is an interposer extending at least partially around the microphone.
8. The circuit board assembly of claim 1, wherein the at least one interposer includes two or more interposers, the interposers positioned on different sides of the microphone.
9. The circuit board assembly of claim 2, wherein the bottom circuit board is a two-layer flex with a stack that includes a first layer of copper, a second layer of polyimide, and a third layer of copper, wherein the second layer of polyimide is in between the first layer and the third layer.
10. The circuit board assembly of claim 1, wherein the at least one interposer includes at least one interposer with four or more vias.
11. The circuit board assembly of claim 1, wherein the at least one interposer includes at least one interposer with five vias that are arranged in a sawtooth pattern.
12. The circuit board assembly of claim 1, wherein the circuit board assembly further comprises filtering and electrical components connected to top circuit board.

13. The circuit board assembly of claim 2, wherein the bottom board is a two-layer flex with a stack that includes a first layer of copper, a second layer of polyimide, and a third layer of copper, wherein the second layer of polyimide is in between the first layer and the third layer.
14. The circuit board assembly of claim 13, wherein the bottom board includes traces, a width of the traces is 50 μm, and a space between the traces is about 75 μm.