



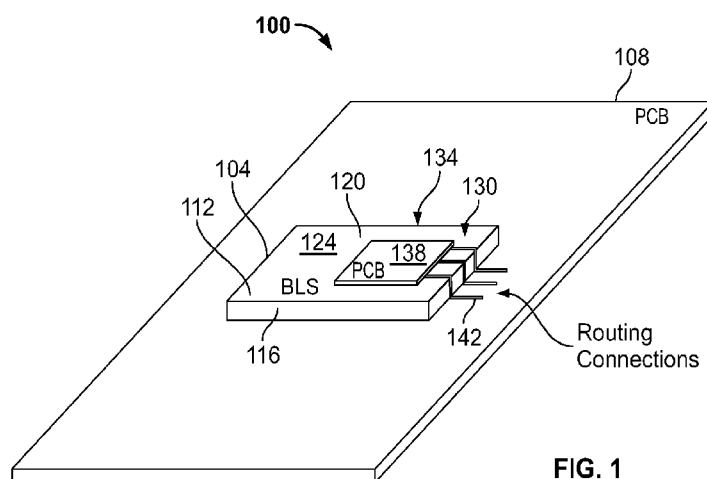
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(54) **Title:** CIRCUIT ASSEMBLIES AND RELATED METHODS**FIG. 1**

(57) **Abstract:** In exemplary embodiments, a circuit assembly may be provided on and/or supported by an electrically conductive structure, such as a board level shield, a midplate, a bracket, a precision metal part, etc. For example, a circuit assembly may be provided on and/or supported by an outer top surface of a board level shield. In an exemplary embodiment, an assembly generally includes an electrically conductive structure configured for a first functionality in the electronic device. An electrically nonconductive layer is on at least part of the electrically conductive structure. First electrical component(s) are at least partly on the electrically nonconductive layer and configured to define at least a portion of a circuit assembly for electrical connection with one or more second electrical components of the electronic device. The electrically conductive structure may thus be configured for a second functionality in the electronic device.



CIRCUIT ASSEMBLIES AND RELATED METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a PCT International Application of U.S. Provisional Patent Application No. 62/147,424 filed April 14, 2015 and U.S. States Patent Application No. 14/704,115 filed May 5, 2015 which, in turn, claims the benefit of and priority to U.S. Provisional Patent Application No. 62/147,424. The entire disclosures of the above applications are incorporated herein by reference.

FIELD

[0002] The present disclosure generally relates to circuit assemblies and related methods.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] The operation of electronic devices generates electromagnetic radiation within the electronic circuitry of the equipment. Such radiation may result in electromagnetic interference (EMI) or radio frequency interference (RFI), which can interfere with the operation of other electronic devices within a particular proximity. Without adequate shielding, EMI/RFI interference may cause degradation or complete loss of important signals, thereby rendering the electronic equipment inefficient or inoperable.

[0005] A common solution to ameliorate the effects of EMI/RFI is through the use of shields capable of absorbing and/or reflecting and/or redirecting EMI energy. These shields are typically employed to localize EMI/RFI within its source, and to insulate other devices proximal to the EMI/RFI source. Where components are provided on a printed circuit board (PCB), a board level shield (BLS) may be installed over one or more PCB components.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] According to various aspects, exemplary embodiments are disclosed of circuit assemblies and related methods. In exemplary embodiments, a circuit assembly may be provided on and/or supported by an electrically conductive structure, such as a board level shield, a

midplate, a bracket, a precision metal part, *etc.* For example, a circuit assembly may be provided on and/or supported by an outer top surface of a board level shield.

[0008] In an exemplary embodiment, an assembly suitable for use in an electronic device generally includes a board level shield (BLS) having an outer surface. Dielectric material is along at least a portion of the outer surface of the BLS. Electrically conductive material is along at least a portion of the dielectric material. The dielectric material is between the electrically conductive material and the outer surface of the BLS. The electrically conductive material is configured to define at least a portion of a circuit assembly for connection with one or more components of the electronic device.

[0009] In an exemplary embodiment, an assembly suitable for use in an electronic device generally includes an electrically conductive structure configured for a first functionality in the electronic device. An electrically nonconductive layer is on at least part of the electrically conductive structure. One or more first electrical components are at least partly on the electrically nonconductive layer and configured to define at least a portion of a circuit assembly for electrical connection with one or more second electrical components of the electronic device. The electrically conductive structure may thus be configured for a second functionality in the electronic device in addition to the first functionality in the electronic device.

[0010] Also disclosed are exemplary embodiments of methods relating to making a circuit assembly suitable for use in an electronic device. In an exemplary embodiment, a method generally includes applying an electrically nonconductive layer on at least part of an electrically conductive structure. The electrically conductive structure is configured to have a first functionality in the electronic device. The method also includes providing one or more first electrical components at least partly on the electrically nonconductive layer. The method further includes configuring the one or more first electrical components for electrical connection with one or more second electrical components of the electronic device. The electrically conductive structure may thus be configured to have a second functionality in addition to the first functionality.

[0011] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0012] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0013] FIG. 1 illustrates an assembly in which there is a multilayer circuit assembly including a flexible circuit along a portion of a board level shield (BLS) according to an exemplary embodiment;

[0014] FIG. 2 illustrates an assembly in which there is a multilayer circuit assembly including routing connections along a portion of a board level shield (BLS) according to an exemplary embodiment;

[0015] FIG. 3 illustrates an assembly that includes both of the multilayer circuit assemblies shown in FIGS. 1 and 2 according to an exemplary embodiment; and

[0016] FIG. 4 illustrates a multilayer circuit assembly including flexible circuits aligned for positioning on an electrically nonconductive or dielectric material along a portion of a mid-plate according to an exemplary embodiment.

DETAILED DESCRIPTION

[0017] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0018] Designers of consumer electronics (*e.g.*, smartphones, *etc.*) strive to make use of all available space inside electronic devices in order to make the devices as thin as possible. Accordingly, the inventors hereof sought to develop, have developed, and disclose herein exemplary embodiments of assemblies that make use of previously unused space to provide a more densely packed electronic device. One way of conserving space inside a device is to provide components that are multifunctional. For example, a smartphone may employ a board level shield (BLS) to provide EMI shielding and/or grounding of electrical components, which may be referred to as a first functionality of the BLS. In exemplary embodiments disclosed herein, the same BLS may also be used to support at least part of a multiple-layer or multilayer electrical circuit assembly. With this second functionality of supporting the electrical circuit assembly, the BLS may thus be multifunctional. Some other example embodiments include multifunctional smartphone mid-plate that is used to provide a ground plane and to isolate a screen from a battery and logic boards (a first functionality) and used to support at least part of a

multiple-layer electrical circuit assembly (a second functionality). A mid-plate may also be referred to herein as a midplate, mid plate, middle deck, or support member. Additionally or alternatively, brackets, and/or other precision metal components can also serve to support at least part of a multilayer electrical circuit. In exemplary embodiments that include a bracket or a precision metal component, the first functionality of the bracket or precision metal component would be structural or mechanical (e.g. to fix another component in place or provide other mechanical function, etc.), and the second functionality would be supporting at least part of an electrical circuit assembly.

[0019] In some exemplary embodiments, a circuit assembly is provided that is suitable for use in an electronic device, such as a smartphone, *etc.* The circuit assembly includes an electrically conductive structure, *e.g.*, a BLS, mid-plate, bracket, other precision metal part, *etc.* In one example embodiment, an electrically nonconductive layer (*e.g.*, a coating of dielectric material or nonconductive paint, *etc.*) covers at least part of an outer surface of a BLS. The electrically nonconductive layer may be thermally conductive in some exemplary embodiments. One or more first electrical components are provided at least partly on (*e.g.*, stacked on, *etc.*) the electrically nonconductive layer. The one or more first electrical components are configured for electrical connection with one or more second electrical components provided, *e.g.*, on a substrate, on a printed circuit board (PCB) onto which the BLS is configured to be installed, *etc.* In various embodiments, the first electrical component(s) could be configured for electrical connection with second electrical component(s) provided directly on the PCB and/or on another substrate. Additionally or alternatively, the first electrical component(s) could be configured for electrical connection with second electrical component(s) provided elsewhere in the circuit assembly.

[0020] By way of example, a multiple-layer circuit assembly may have x and y dimensions similar to the dimensions of a BLS dimensions, *e.g.*, on the order of 2 millimeters (mm), *etc.* The z dimension of the multiple-layer circuit assembly may be on the order of a few mils. Exemplary embodiments disclosed herein may be used to avoid having to add another circuit board that would take up more space inside the smartphone or other electronic device. Accordingly, exemplary embodiments disclosed herein may allow for a better use of the existing space in three dimensions.

[0021] Some exemplary embodiments include an electrically nonconductive or dielectric layer that is thermally conductive. These exemplary embodiments may have a third functionality, which is defining or providing part of a thermally-conductive heat path from a heat source to a heat dissipating device or component.

[0022] FIG. 1 illustrates an exemplary embodiment of an assembly 100 for an electronic device such as smartphone, tablet, *etc.* The assembly 100 includes an electrically conductive structure. In this example, the electrically conductive structure is a board level shield (BLS) 104 attached to a substrate 108 (*e.g.*, a printed circuit board (PCB), *etc.*). In other embodiments, the electrically conductive structure may comprise a mid-plate, a bracket, a metal precision piece, *etc.*

[0023] As shown in FIG. 1, the BLS 104 includes a cover 112 (broadly, a top or upper surface) and sidewalls 116 depending from (*e.g.*, attached to, integrally connected with, *etc.*) the cover 112. The sidewalls 116 are configured for installation to the substrate 108 generally about one or more components (not shown) on the substrate 108 such that the component(s) are under the BLS 104 and/or within an interior or shielding enclosure cooperatively defined by the sidewalls 116 and the cover 112. When the BLS 104 is installed (*e.g.*, soldered, *etc.*) on the substrate 108, the BLS 104 is operable for shielding the component(s) that are within the interior or shielding enclosure cooperatively defined by the sidewalls 116 and the cover 112. The BLS 104 may also serve as a ground plane. In various embodiments, a BLS cover and one or more sidewalls depending from the cover are formed from a single piece of electrically conductive material such that the BLS cover and the sidewall(s) have a monolithic or single piece construction. Alternative embodiments may include a multipiece BLS in which the cover or upper surface may be made separately and not integrally with the sidewalls. In some embodiments, the BLS may comprise a two-piece shield in which the shield's cover or lid is removable from and reattachable to the sidewalls.

[0024] An electrically nonconductive or dielectric material 120 is applied to at least part of one or more outer surfaces 124 of the cover 112 and/or sidewalls 116 of the BLS 104. The electrically nonconductive layer may be thermally conductive in some exemplary embodiments. In other exemplary embodiments, the electrically nonconductive layer may be a thermal insulator.

[0025] Electrically conductive material 130 is provided at least partly on the nonconductive material 120. The electrically conductive material 130 is configured to define at least a portion of a circuit assembly for connection with one or more components of the electronic device. The electrically conductive material 130 may also define and/or be referred to herein as one or more electrical components 130 (“first electrical components”).

[0026] The dielectric material 120 may be a relatively thin dielectric coating or layer that is applied via ink jet printing, spraying, painting, *etc.* The dielectric material 120 (*e.g.*, a dielectric coating, electrical insulation, *etc.*) provides electrical isolation between the BLS 104 and the electrically conductive material 130. The dielectric material 120 acts as an intermediary between the BLS 104 and the electrically conductive material 130 to prevent direct contact between the BLS 104 and the electrically conductive material 130. By way of example, a dielectric coating may be deposited or dispensed along the outer surface of the BLS 104, *e.g.*, via an ink jet process, print nozzle, or other suitable process. The dielectric coating may then be cured with ultraviolet light, *etc.* In an exemplary embodiment, the dielectric coating may provide electrical resistance greater than 4 gigaohms at 1000 volts with a 1 mm probe tip diameter and 100 gram weight. The dielectric coating may be capable of withstanding or surviving lead-free reflow temperatures, such as a temperature of at least 260 degrees Celsius (*e.g.*, 300 degrees Celsius, 350 degrees Celsius, *etc.*). The dielectric coating may comprise a blend of polymers, with acrylate polymers as the primary component, along with other components urethane, polyester and polyvinyl polymers, photo initiators, and other additives, *etc.* The dielectric coating may be disposed along the entire outer surface of the BLS or along only portions of the outer surface of the BLS. For example, the dielectric coating may be disposed along the outer surface of the cover 112 and one sidewall 116, along the cover 112 and two opposing sidewalls, or along the cover 112 and all four sidewalls 116. The dielectric coating may have a thickness of about 15 microns, less than 15 microns, or greater than 15 microns. The dielectric coating may be thermally conductive in some exemplary embodiments.

[0027] The dielectric material 120 may be provided at least partly along and/or over the outward-facing exposed surface(s) 124 of the BLS 104, such that the dielectric material 120 is situated between the BLS 104 and the first electrical component(s) 130 provided at least partly on the electrically nonconductive or dielectric material 120. The dielectric material 120 inhibits

the BLS 104 from directly contacting and electrically shorting the first electrical component(s) 130.

[0028] In this example, the first electrical component(s) 130 include a flexible circuit 134 provided at least in part on a flexible PCB 138. The flexible circuit 134 may be made of materials including, *e.g.*, polyimide film (such as Kapton polyimide, *etc.*), adhesive, metal foil, *etc.* The flexible PCB 138 is mounted on the cover 112 of the BLS 104. Connectors 142 extend from the flexible PCB 138, *e.g.*, over one of the sidewall(s) 116. The connectors 142 may be patterned onto the electrically nonconductive material 120 on the BLS cover 112 and sidewall 116, *e.g.*, with electrically conductive paint and/or other electrically conductive material. The connectors 142 may be used to electrically connect the flexible circuit 134 with various electrical components (“second electrical components”) (not shown in FIG. 1) including, *e.g.*, one or more second electrical components installed directly on the PCB 108, installed on another PCB, installed on the BLS 104, installed apart from the PCB 108, installed on other component(s) elsewhere in the circuit assembly 100, *etc.*

[0029] In some exemplary embodiments, the electrically nonconductive or dielectric material 120 may also be thermally conductive. In these exemplary embodiments, the assembly 100 may have a third functionality as it can be used to help define or provide part of a thermally-conductive heat path from a heat source to a heat dissipating device or component (*e.g.*, a heat spreader, a heat sink, a heat pipe, a device exterior case or housing, *etc.*). For example, a thermally conductive heat path may be defined from one or more heat generating components disposed under the BLS 104 through the BLS cover 112 and/or sidewalls 116 and thermally-conductive dielectric material 120 to a heat dissipating device.

[0030] FIG. 2 illustrates another exemplary embodiment of an assembly 200 for an electronic device such as smartphone, tablet, *etc.* The assembly 200 includes an electrically conductive structure. In this example, the electrically conductive structure is a board level shield (BLS) 204 attached to a substrate 208 (*e.g.*, a printed circuit board (PCB), *etc.*). In other embodiments, the electrically conductive structure may comprise a mid-plate, a bracket, a metal precision piece, *etc.*

[0031] As shown in FIG. 2, the BLS 204 includes a cover 212 (broadly, a top or upper surface) and sidewalls 216 depending from (*e.g.*, attached to, integrally connected with, *etc.*) the cover 212. The sidewalls 216 are configured for installation to the substrate 208

generally about one or more components (not shown) on the substrate 208 such that the component(s) are under the BLS 204 and/or within an interior or shielding enclosure cooperatively defined by the sidewalls 216 and the cover 212. When the BLS 204 is installed (*e.g.*, soldered, *etc.*) on the substrate 208, the BLS 204 is operable for shielding the component(s) that are within the interior or shielding enclosure cooperatively defined by the sidewalls 216 and the cover 212. The BLS 204 may also serve as a ground plane.

[0032] An electrically nonconductive or dielectric material 220 is applied to at least part of one or more outer surfaces 224 of the cover 112 and/or sidewalls 116 of the BLS 204. The dielectric material 220 may be thermally conductive or thermally insulative. One or more electrical components 230 (“first electrical components”) are provided at least partly on the nonconductive layer 220. The dielectric material 220 may be a relatively thin dielectric coating or layer that is applied via ink jet printing, spraying, painting, *etc.* The dielectric material 220 (*e.g.*, a dielectric coating, electrical insulation, *etc.*) provides electrical isolation between the BLS 204 and the electrically conductive material 230. The dielectric material 220 acts as an intermediary between the BLS 204 and the electrically conductive material 230 to prevent direct contact between the BLS 204 and the electrically conductive material 230. By way of example, a dielectric coating may be deposited or dispensed along the outer surface of the BLS 204, *e.g.*, via an ink jet process, print nozzle, or other suitable process. The dielectric coating may then be cured with ultraviolet light, *etc.* In an exemplary embodiment, the dielectric coating may provide electrical resistance greater than 4 gigaohms at 1000 volts with a 1 mm probe tip diameter and 100 gram weight. The dielectric coating may be capable of withstanding or surviving lead-free reflow temperatures, such as a temperature of at least 260 degrees Celsius (*e.g.*, 300 degrees Celsius, 350 degrees Celsius, *etc.*). The dielectric coating may comprise a blend of polymers, with acrylate polymers as the primary component, along with other components urethane, polyester and polyvinyl polymers, photo initiators, and other additives, *etc.* The dielectric coating may be disposed along the entire outer surface of the BLS or along only portions of the outer surface of the BLS. The dielectric coating may have a thickness of about 15 microns, less than 15 microns, or greater than 15 microns. The dielectric coating may be thermally conductive in some exemplary embodiments.

[0033] The dielectric material 220 may be provided at least partly along and/or over the outward-facing exposed surface(s) 224 of the BLS 204, such that the dielectric material 220

is situated between the BLS 204 and the first electrical component(s) 230 and provided at least partly on the electrically nonconductive material 220. The dielectric material 220 inhibits the BLS 204 from directly contacting and electrically shorting the first electrical component(s) 230.

[0034] In the example, the first electrical component(s) 230 include routing connectors 242 extending, *e.g.*, at least partly across the BLS 204 from one sidewall 116 over the cover 212 to an opposite sidewall 116. The connectors 242 may be patterned on the BLS 204 over the dielectric material 220, *e.g.*, with electrically conductive paint and/or other electrically conductive material. The connectors 242 may be used to electrically interconnect various electrical components (“second electrical components”) (not shown in FIG. 2) including, *e.g.*, component(s) installed directly or indirectly on the PCB 208, installed on another PCB, installed on the BLS 204, installed apart from the PCB 208, installed on other component(s) elsewhere in the circuit assembly 200, *etc.*

[0035] In some exemplary embodiments, the electrically nonconductive or dielectric material 220 may also be thermally conductive. In these exemplary embodiments, the assembly 200 may have a third functionality as it can be used to help define or provide part of a thermally-conductive heat path from a heat source to a heat dissipating device or component (*e.g.*, a heat spreader, a heat sink, a heat pipe, a device exterior case or housing, *etc.*). For example, a thermally conductive heat path may be defined from one or more heat generating components disposed under the BLS 204 through the BLS cover 212 and/or sidewalls 216 and thermally-conductive dielectric material 220 to a heat dissipating device.

[0036] FIG. 3 illustrates another exemplary embodiment of an assembly 300 for an electronic device such as smartphone, tablet, *etc.* In this example, the assembly 300 includes the assemblies 100 and 200, which are identical or similar to the corresponding assemblies 100 and 200 described above and shown in FIGS. 1 and 2, respectively.

[0037] FIG. 4 illustrates an exemplary embodiment of an assembly 400 for an electronic device such as smartphone, tablet, *etc.* The assembly 400 includes an electrically conductive structure. In this example, the electrically conductive structure is a mid-plate 404. In other embodiments, the electrically conductive structure may comprise a board level shield (BLS), a bracket, a metal precision piece, *etc.*

[0038] As shown in FIG. 4, a heat spreader 446 (*e.g.*, graphite, *etc.*) is disposed within a pocket or recessed portions of the mid-plate 404. An electrically nonconductive or

dielectric material 420 is applied to at least part of one or more outer surfaces 424 of the mid-plate 404 and/or to at least part of one or more outer surfaces 426 of the heat spreader 446. The electrically nonconductive layer 420 may be thermally conductive such that a thermally-conductive heat path is defined through the mid-plate 404, heat spreader 446, and thermally-conductive electrically non-conductive layer 420.

[0039] Electrically conductive material is provided at least partly on the nonconductive material 420. The electrically conductive material is configured to define at least a portion of a circuit assembly for connection with one or more components of the electronic device. The electrically conductive material may also define and/or be referred to herein as one or more electrical components (“first electrical components”).

[0040] In this example, the first electrical component(s) include two flexible circuits 434 provided at least in part on flexible PCBs 438. The flexible circuits 434 may be made of materials including, *e.g.*, polyimide film (such as Kapton polyimide, *etc.*), adhesive, metal foil, *etc.* Connectors 442 extend outwardly from the flexible PCBs 438. The connectors 442 may be used to electrically connect the flexible circuits 434 with various electrical components (“second electrical components”) (not shown in FIG. 4) including, *e.g.*, one or more second electrical components installed directly on a PCB, *etc.*

[0041] The dielectric material 420 may be a relatively thin dielectric coating or layer that is applied via ink jet printing, spraying, painting, *etc.* The dielectric material 420 (*e.g.*, a dielectric coating, electrical insulation, *etc.*) electrically isolates the flexible circuits 434 and connectors 442 from the mid-plate 404 and the heat spreader 446. The dielectric material 420 acts as an intermediary to prevent direct contact and electrical shorting of the flexible circuits 434 and connectors 442 with the mid-plate 404 and the heat spreader 446. By way of example, a dielectric coating may be deposited or dispensed along the outer surface of the mid-plate 404, *e.g.*, via an ink jet process, print nozzle, or other suitable process. The dielectric coating may then be cured with ultraviolet light, *etc.* In an exemplary embodiment, the dielectric coating may provide electrical resistance greater than 4 gigaohms at 1000 volts with a 1 mm probe tip diameter and 100 gram weight. The dielectric coating may be capable of withstanding or surviving lead-free reflow temperatures, such as a temperature of at least 260 degrees Celsius (*e.g.*, 300 degrees Celsius, 350 degrees Celsius, *etc.*). The dielectric coating may comprise a blend of polymers, with acrylate polymers as the primary component, along with other components

urethane, polyester and polyvinyl polymers, photo initiators, and other additives, *etc.* The dielectric coating may be disposed along the entire outer surface of the mid-plate or along only portions of the outer surface of the mid-plate. The dielectric coating may have a thickness of about 15 microns, less than 15 microns, or greater than 15 microns. The dielectric coating may be thermally conductive in some exemplary embodiments.

[0042] In some exemplary embodiments, the dielectric material 420 may also be thermally conductive. In these exemplary embodiments, the assembly 400 may have a third functionality as it can be used to help define or provide part of a thermally-conductive heat path from a heat source to a heat dissipating device or component (*e.g.*, a heat spreader, a heat sink, a heat pipe, a device exterior case or housing, *etc.*). For example, a thermally conductive heat path may be defined from one or more heat sources through the mid-plate 404, heat spreader 446, and thermally-conductive dielectric material 420 to a heat dissipating device.

[0043] In various embodiments, a BLS, mid-plate, bracket, precision metal component, *etc.* disclosed herein may be formed from a wide range of materials, which are preferably electrically conductive materials. For example, a BLS and/or mid-plate may be formed from metals or metal alloys, such as cold rolled steel (*e.g.*, tin-plated cold rolled steel, *etc.*), sheet metal, stainless steel, copper alloys (*e.g.*, tin-plated copper alloys, *etc.*), nickel-silver alloys (*e.g.*, nickel-silver alloy 770, *etc.*), copper-nickel alloys, carbon steel, brass, copper, aluminum, copper-beryllium alloys, phosphor bronze, steel, alloys thereof, among other suitable electrically conductive materials. A BLS and/or mid-plate may also be formed from a plastic material coated with electrically conductive material. In one exemplary embodiment, a BLS and/or mid-plate may be formed from a sheet of nickel-silver alloy having a thickness of about 0.15 millimeters. The materials and dimensions provided herein are for purposes of illustration only, as a BLS and/or a mid-plate disclosed herein may be made from different materials and/or have different dimensions depending, for example, on the particular application, such as electrical components to be shielded, space considerations within the overall electronic device, EMI shielding and heat dissipation needs, and other factors.

[0044] Also disclosed are exemplary embodiments of methods relating to making a multiple-layer circuit assembly suitable for use in an electronic device such as a smartphone. One example method generally includes applying an electrically nonconductive layer onto at least part of an electrically conductive structure, *e.g.*, a BLS, mid-plate, bracket, precision metal

part, *etc.* In various example methods, dielectric material may be provided over and/or along the outward-facing exposed surface(s) of the electrically conductive structure. The dielectric material inhibits the electrically conductive structure from directly contacting and electrically shorting one or more components as the components would instead contact the dielectric material. Example methods may include depositing a dielectric via ink jet printing, spraying, painting, *etc.* An exemplary embodiment may include ink jet printing a relatively thin dielectric coating (*e.g.*, 5 microns thick, *etc.*) and then curing the dielectric coating with ultraviolet light. The dielectric coating may be thermally conductive in some exemplary embodiments.

[0045] Apart from being configured (in accordance with the present example method) for use in a multiple-layer circuit assembly, the electrically conductive structure is configured to have a first functionality in the electronic device. For example, as previously mentioned, a BLS may be provided to shield electrical components, and a mid-plate may be provided to separate a smartphone screen from a battery and/or logic board(s). The example method also includes providing one or more first electrical components at least partly on the electrically nonconductive layer. The first electrical component(s) are configured for electrical connection with one or more second electrical components provided, *e.g.*, on a substrate. For example, where the electrically conductive structure is a BLS configured for installation on a substrate such as a PCB, the first electrical component(s) may be configured for connection with second electrical component(s) installed on the same PCB. Through performance of the foregoing method, the electrically conductive structure is configured to have a second functionality in addition to the first functionality. For example, a BLS included in a multiple-layer circuit assembly not only may provide shielding, but also may provide support for at least some of the electrical components in the circuit assembly. In this example, the first and second functionalities may thus be considered to be shielding and electrical component support, respectively.

[0046] The term “EMI” as used herein should be considered to generally include and refer to EMI emissions and RFI emissions, and the term “electromagnetic” should be considered to generally include and refer to electromagnetic and radio frequency from external sources and internal sources. Accordingly, the term shielding (as used herein) broadly includes and refers to mitigating (or limiting) EMI and/or RFI, such as by absorbing, reflecting, blocking, and/or redirecting the energy or some combination thereof so that it no longer interferes, for example, for government compliance and/or for internal functionality of the electronic component system.

[0047] Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms, and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail. In addition, advantages and improvements that may be achieved with one or more exemplary embodiments of the present disclosure are provided for purposes of illustration only and do not limit the scope of the present disclosure, as exemplary embodiments disclosed herein may provide all or none of the above mentioned advantages and improvements and still fall within the scope of the present disclosure.

[0048] Specific dimensions, specific materials, and/or specific shapes disclosed herein are example in nature and do not limit the scope of the present disclosure. The disclosure herein of particular values and particular ranges of values for given parameters are not exclusive of other values and ranges of values that may be useful in one or more of the examples disclosed herein. Moreover, it is envisioned that any two particular values for a specific parameter stated herein may define the endpoints of a range of values that may be suitable for the given parameter (*i.e.*, the disclosure of a first value and a second value for a given parameter can be interpreted as disclosing that any value between the first and second values could also be employed for the given parameter). For example, if Parameter X is exemplified herein to have value A and also exemplified to have value Z, it is envisioned that parameter X may have a range of values from about A to about Z. Similarly, it is envisioned that disclosure of two or more ranges of values for a parameter (whether such ranges are nested, overlapping or distinct) subsume all possible combination of ranges for the value that might be claimed using endpoints of the disclosed ranges. For example, if parameter X is exemplified herein to have values in the range of 1 – 10, or 2 – 9, or 3 – 8, it is also envisioned that Parameter X may have other ranges of values including 1 – 9, 1 – 8, 1 – 3, 1 – 2, 2 – 10, 2 – 8, 2 – 3, 3 – 10, and 3 – 9.

[0049] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a”, “an” and “the” may be intended to include the plural forms as well, unless the context

clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0050] When an element or layer is referred to as being “on”, “engaged to”, “connected to” or “coupled to” another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly engaged to”, “directly connected to” or “directly coupled to” another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (*e.g.*, “between” versus “directly between,” “adjacent” versus “directly adjacent,” *etc.*). As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0051] The term “about” when applied to values indicates that the calculation or the measurement allows some slight imprecision in the value (with some approach to exactness in the value; approximately or reasonably close to the value; nearly). If, for some reason, the imprecision provided by “about” is not otherwise understood in the art with this ordinary meaning, then “about” as used herein indicates at least variations that may arise from ordinary methods of measuring or using such parameters. For example, the terms “generally”, “about”, and “substantially” may be used herein to mean within manufacturing tolerances. Whether or not modified by the term “about”, the claims include equivalents to the quantities.

[0052] Although the terms first, second, third, *etc.* may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element,

component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0053] Spatially relative terms, such as “inner,” “outer,” “beneath”, “below”, “lower”, “above”, “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0054] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements, intended or stated uses, or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

CLAIMS

WHAT IS CLAIMED IS:

1. An assembly suitable for use in an electronic device, the assembly comprising:
a board level shield (BLS) having an outer surface;
dielectric material along at least a portion of the outer surface of the BLS; and
electrically conductive material along at least a portion of the dielectric material such that the dielectric material is between the electrically conductive material and the outer surface of the BLS, whereby the electrically conductive material is configured to define at least a portion of a circuit assembly for connection with one or more components of the electronic device.
2. The assembly of claim 1, wherein the dielectric material is thermally conductive.
3. The assembly of claim 1, wherein the dielectric material comprises one or more of a printed dielectric surface, a sprayed dielectric surface, and/or a painted dielectric surface.
4. The assembly of claim 1, wherein:
the electrically conductive material comprises one or more of a flexible circuit, a pattern of electrically conductive material, and/or one or more routing connections; and
the electrically conductive material is connected or connectible between two or more electrical components.
5. The assembly of claim 1, wherein the electrically conductive material comprises a flexible circuit including one or more of a polyimide film, an adhesive, and/or a metal foil.
6. The assembly of any one of the preceding claims, wherein:
the BLS is configured for installation to a substrate for providing electromagnetic interference (EMI) shielding for one or more components on the substrate; and
the electrically conductive material is configured for electrical connection with one or more other components on the same substrate that are not under the BLS when the BLS is installed to the substrate;
whereby the BLS is multifunctional having a first functionality of providing EMI shielding and a second functionality of supporting the circuit assembly.
7. The assembly of any one of claims 1 to 5, wherein:
the BLS comprises a cover and one or more sidewalls depending from the cover;
the dielectric material is along at least a portion of an outer surface of the cover; and

the electrically conductive material defines at least a portion of the circuit assembly along the cover of the BLS.

8. The assembly of claim 7, wherein:

the dielectric material is along at least a portion of an outer surface of at least one sidewall of the one or more sidewalls; and

the electrically conductive material defines at least a portion of the circuit assembly along the at least one sidewall.

9. The assembly of claim 8, wherein:

the BLS is configured for installation to a first printed circuit board (PCB);

the assembly further comprises a second printed circuit board (PCB) on the outer surface of the cover or on the dielectric material along the outer surface of the cover; and

the electrically conductive material extends from the second PCB along the cover and the at least one side wall of the BLS to the first PCB for electrically connecting one or more components of the first PCB with one or more components of the second PCB.

10. The assembly of claim 7, wherein:

the dielectric material is along at least a portion of an outer surface of at least two opposing sidewalls of the one or more sidewalls; and

the electrically conductive material defines one or more routing connections between the two opposing sidewalls across the cover of the BLS.

11. The assembly of any one of claims 1 to 5, wherein:

the dielectric material is directly on the at least a portion of the outer surface of the BLS; and

the electrically conductive material is directly on the at least a portion of the dielectric material.

12. An electronic device comprising the assembly of any one of claims 1 to 5, a printed circuit board (PCB), one or more first components on the PCB, and one or more second components on the PCB, wherein the BLS is installed on the PCB for providing electromagnetic interference (EMI) shielding for the one or more first components on the PCB, and wherein the electrically conductive material is electrically connected with the one or more second components on the PCB.

13. An assembly suitable for use in an electronic device, the assembly comprising:

an electrically conductive structure configured for a first functionality in the electronic device;

an electrically nonconductive layer on at least part of the electrically conductive structure; and

one or more first electrical components at least partly on the electrically nonconductive layer and configured to define at least a portion of a circuit assembly for electrical connection with one or more second electrical components of the electronic device;

whereby the electrically conductive structure is configured for a second functionality in addition to the first functionality in the electronic device.

14. The assembly of claim 13, wherein the electrically conductive structure comprises one or more of a board level shield (BLS), a mid-plate, and/or a bracket.

15. The assembly of claim 13, wherein the dielectric material is thermally conductive

16. The assembly of claim 13, wherein the electrically conductive structure comprises a board level shield (BLS) configured for installation to a substrate for providing electromagnetic interference (EMI) shielding for one or more components on the substrate, whereby the first functionality of the BLS is EMI shielding and the second functionality of the BLS is supporting the circuit assembly.

17. The assembly of any one of claims 13 to 16, wherein:

the electrically nonconductive layer comprises one or more of a printed dielectric surface, a sprayed dielectric surface, and/or a painted dielectric surface; and/or

the one or more first electrical components comprise one or more of a flexible circuit, a pattern of electrically conductive material, and/or one or more routing connections; and

the one or more first electrical components are connected or connectible between two or more electrical components.

18. An electronic device comprising the assembly of any one of claims 13 to 16, a printed circuit board (PCB), wherein the one or more second electrical components are on the PCB, and wherein the one or more first electrical components are electrical connected with the one or more second electrical components on the PCB.

19. A method of making a circuit assembly suitable for use in an electronic device, the method comprising:

applying an electrically nonconductive layer on at least part of an electrically conductive structure, the electrically conductive structure configured to have a first functionality in the electronic device;

providing one or more first electrical components at least partly on the electrically nonconductive layer; and

configuring the one or more first electrical components for electrical connection with one or more second electrical components of the electronic device;

whereby the electrically conductive structure is configured to have a second functionality in addition to the first functionality.

20. The method of claim 19, wherein:

applying the electrically nonconductive layer comprises one or more of printing at least part of the electrically nonconductive layer; and/or spraying at least part of the electrically nonconductive layer; and/or painting at least part of the electrically nonconductive layer; and/or

providing the one or more first electrical components comprises one or more of installing a flexible circuit on the electrically nonconductive layer; and/or patterning a top surface of the electrically nonconductive layer with electrically conductive paint; and/or

the electrically conductive structure comprises a board level shield (BLS) configured for installation to a substrate for providing electromagnetic interference (EMI) shielding for one or more components on the substrate, whereby the first functionality of the BLS is EMI shielding and the second functionality of the BLS is supporting the circuit assembly; and/or

configuring the one or more first electrical components for electrical connection comprises configuring the one or more first electrical components as routing connectors.

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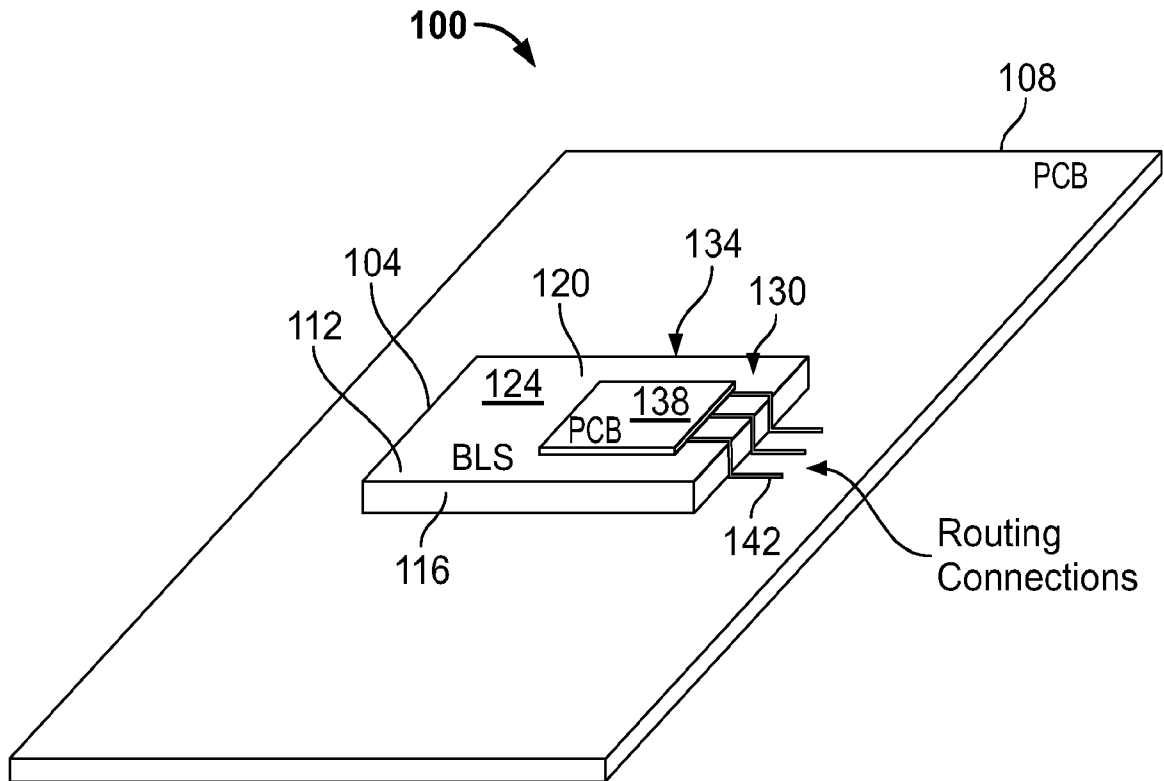


FIG. 1

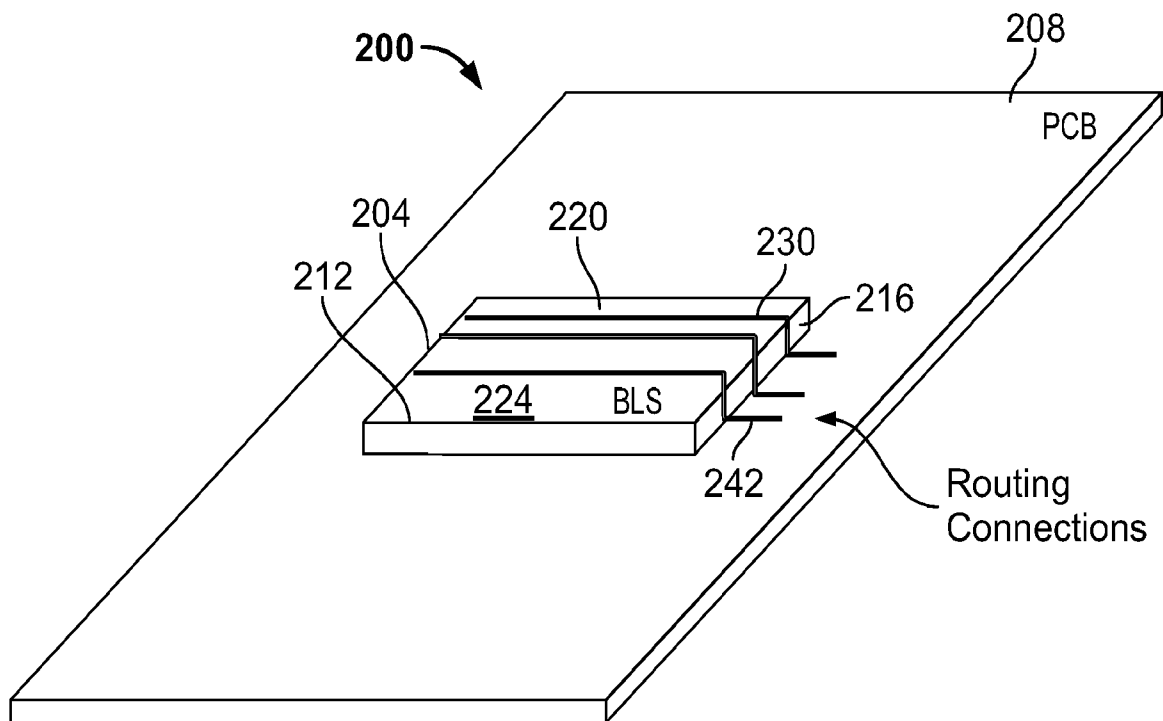


FIG. 2

2/2

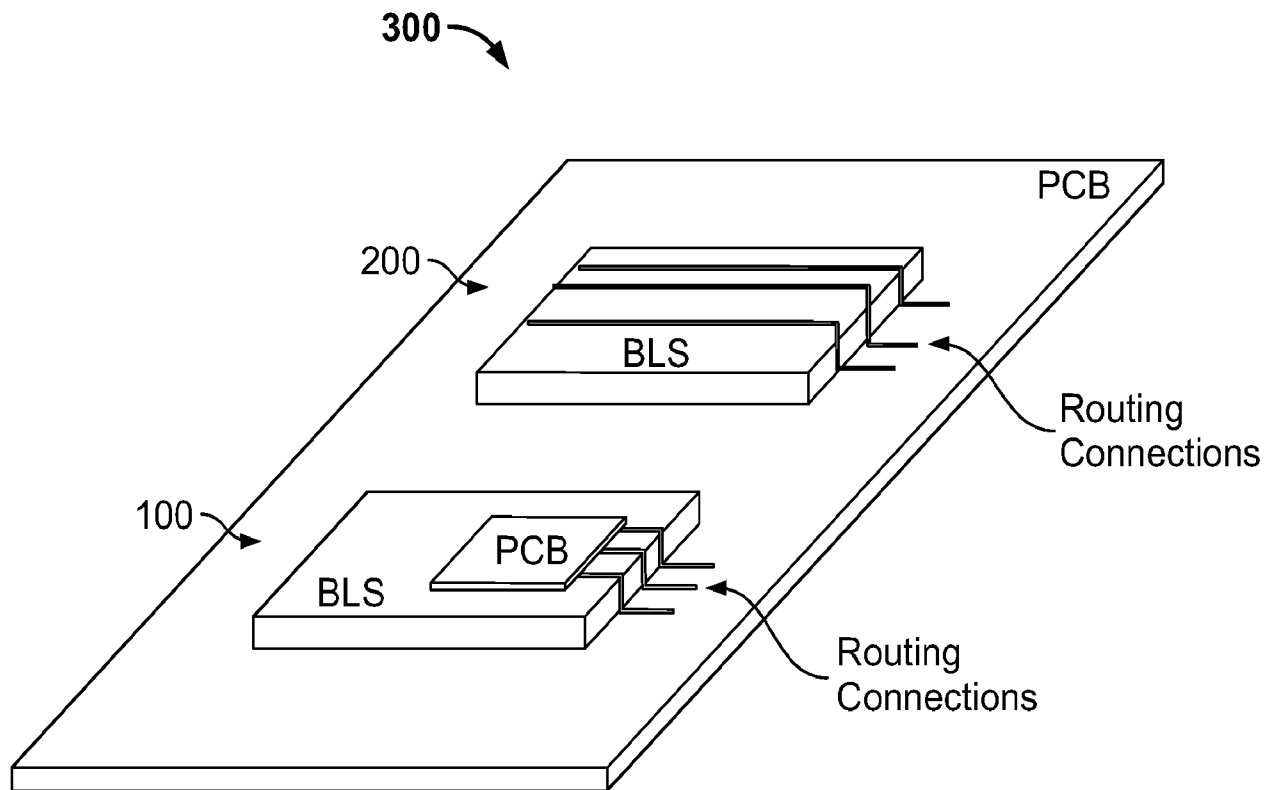


FIG. 3

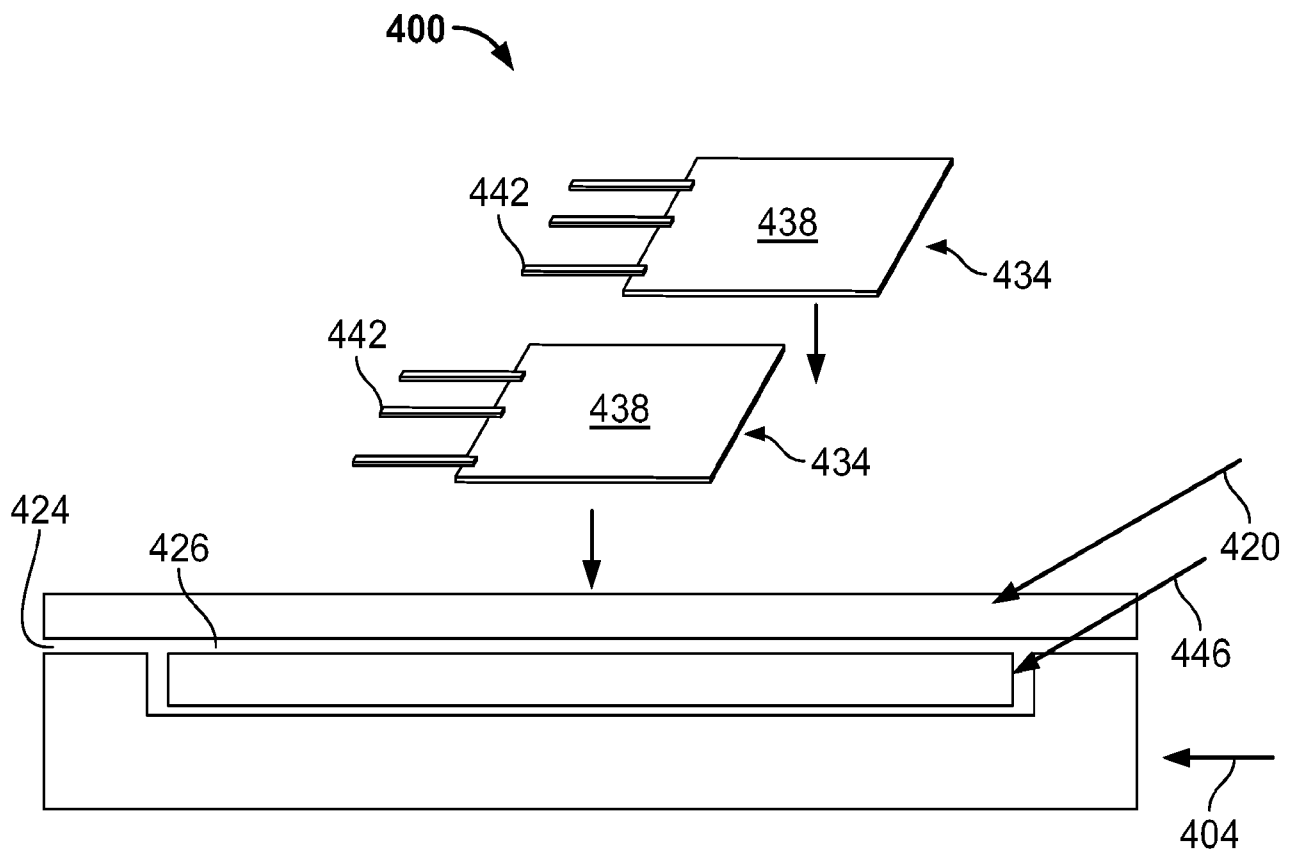


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/014739**A. CLASSIFICATION OF SUBJECT MATTER****H05K 9/00(2006.01)i, H05K 5/02(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)

H05K 9/00; H01L 29/82; C25D 5/02; H01L 25/00; H05K 5/02

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: shield, dielectric, board, circuit, conductive, polymer, foil, component, cover, interference

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003-0193794 A1 (BRADLEY REIS et al.) 16 October 2003 See paragraphs [0012], [0025]-[0030] and figures 3-5.	1-20
A	US 2004-0155308 A1 (JEFFREY MCFADDEN et al.) 12 August 2004 See abstract, paragraphs [0027]-[0032] and figures 1A-2.	1-20
A	US 2007-0209833 A1 (GERALD ROBERT ENGLISH) 13 September 2007 See abstract, paragraphs [0034]-[0057] and figures 1-5.	1-20
A	US 2009-0067149 A1 (BOGURSKY ROBERT et al.) 12 March 2009 See abstract, paragraphs [0075]-[0109] and figures 1A-3I.	1-20
A	JP 2009-094119 A (HITACHI LTD.) 30 April 2009 See abstract, paragraphs [0015]-[0031] and figures 1-7.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

23 May 2016 (23.05.2016)

Date of mailing of the international search report

24 May 2016 (24.05.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

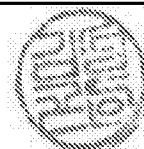
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/014739

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