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**Lim et al.**

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(54) **SEMICONDUCTOR DEVICE AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE**

(58) **Field of Classification Search**

CPC ..... H01L 25/105; H01L 23/5386  
See application file for complete search history.

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(56)

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(51) **Int. Cl.**

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**H01L 21/52** (2006.01)

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(52) **U.S. Cl.**

CPC ..... **H01L 25/105** (2013.01); **H01L 21/52** (2013.01); **H01L 21/56** (2013.01);

(Continued)

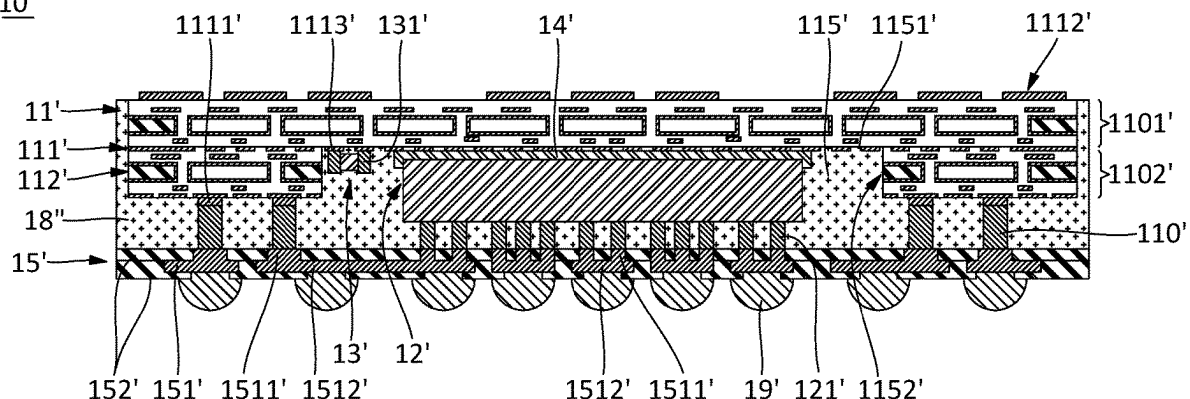
(57)

**ABSTRACT**

In one example, a semiconductor structure comprises a frontside substrate comprising a conductive structure, a backside substrate comprising a base substrate and a cavity substrate contacting the base substrate, wherein the backside substrate is over a top side of the frontside substrate and has a cavity and an internal interconnect contacting the frontside substrate, and a first electronic component over the top side of the frontside substrate and in the cavity. The first electronic component is coupled with the conductive structure, and an encapsulant is in the cavity and on the top side of the frontside substrate, contacting a lateral side of the first electronic component, a lateral side of the cavity, and a lateral side of the internal interconnect. Other examples and related methods are also disclosed herein.

**20 Claims, 19 Drawing Sheets**

10''



**Related U.S. Application Data**

which is a continuation of application No. 16/530,305, filed on Aug. 2, 2019, now Pat. No. 11,171,127.

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**H01L 23/00** (2006.01)  
**H01L 23/31** (2006.01)  
**H01L 23/498** (2006.01)  
**H01L 23/538** (2006.01)

(52) **U.S. Cl.**

CPC .... **H01L 23/3128** (2013.01); **H01L 23/49822** (2013.01); **H01L 23/49838** (2013.01); **H01L 23/5386** (2013.01); **H01L 24/16** (2013.01); **H01L 24/48** (2013.01); **H01L 2224/16227** (2013.01); **H01L 2224/48227** (2013.01); **H01L 2225/1058** (2013.01)

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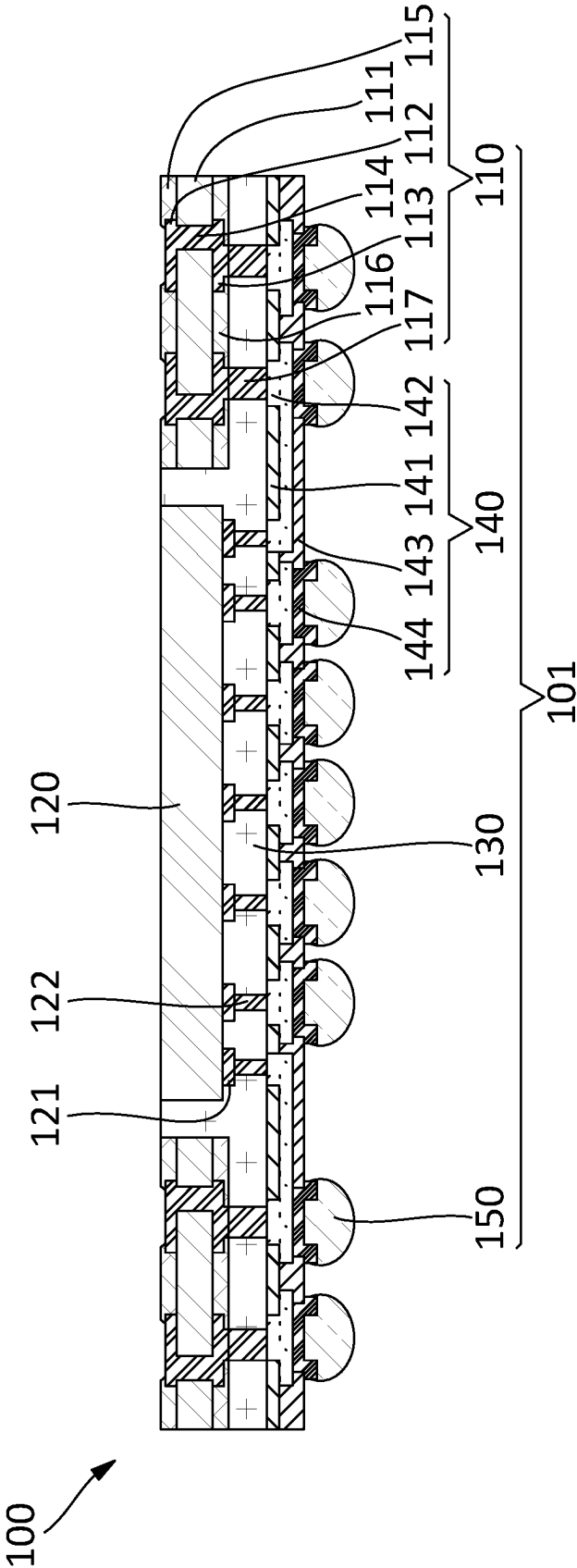


FIG. 1

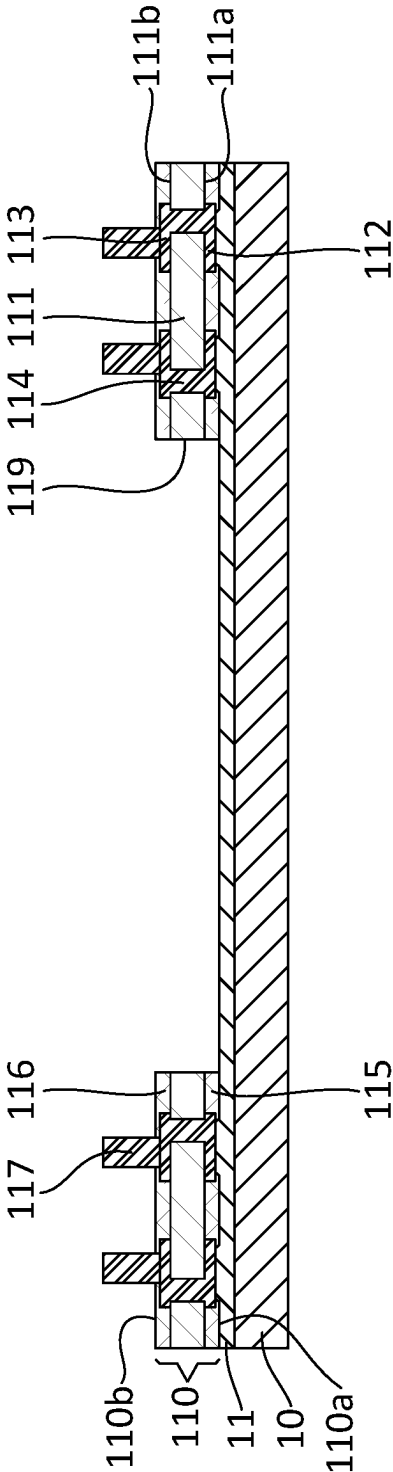


FIG. 2A

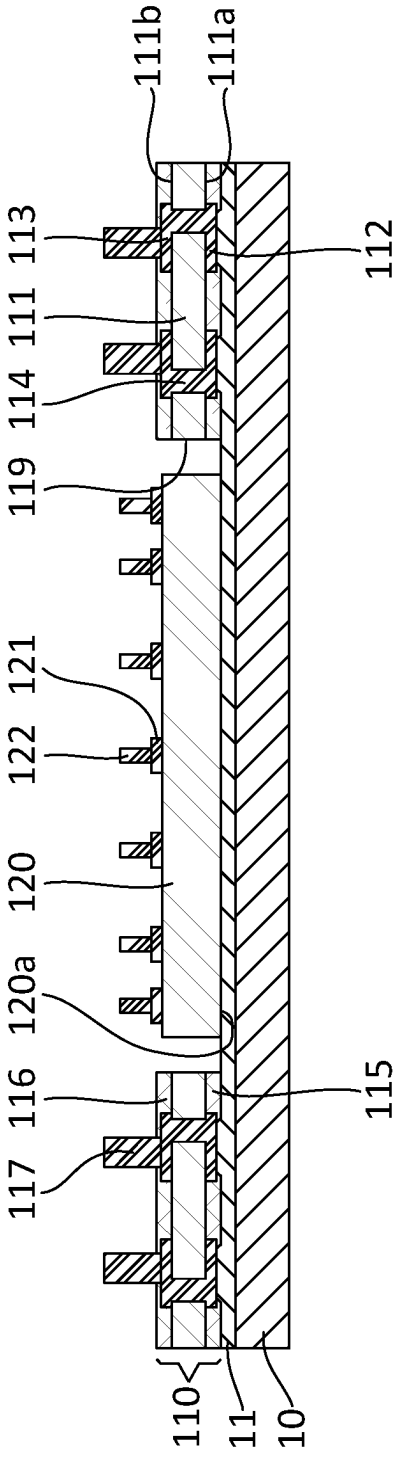


FIG. 2B

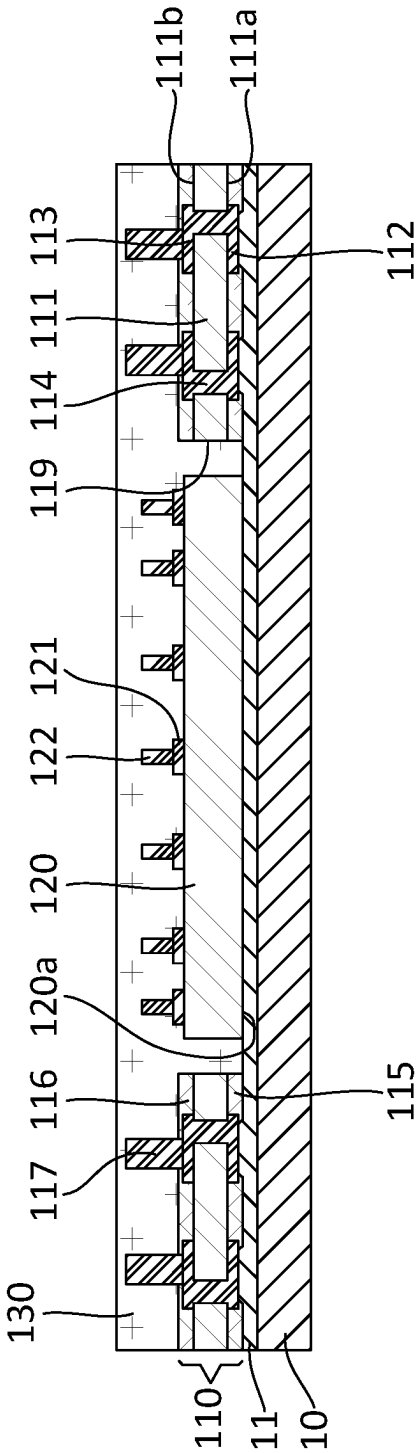


FIG. 2C

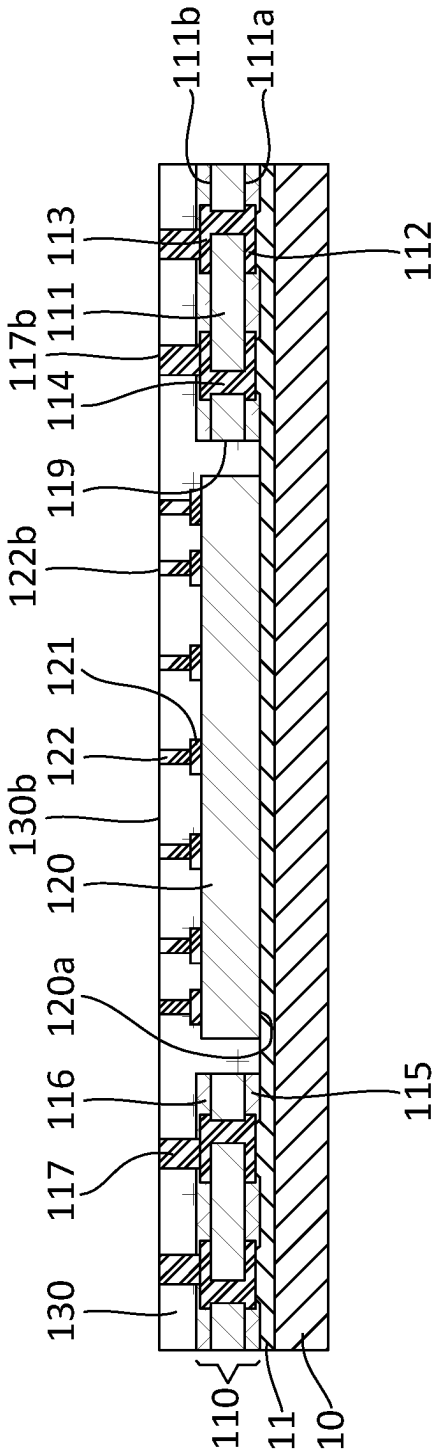


FIG. 2D

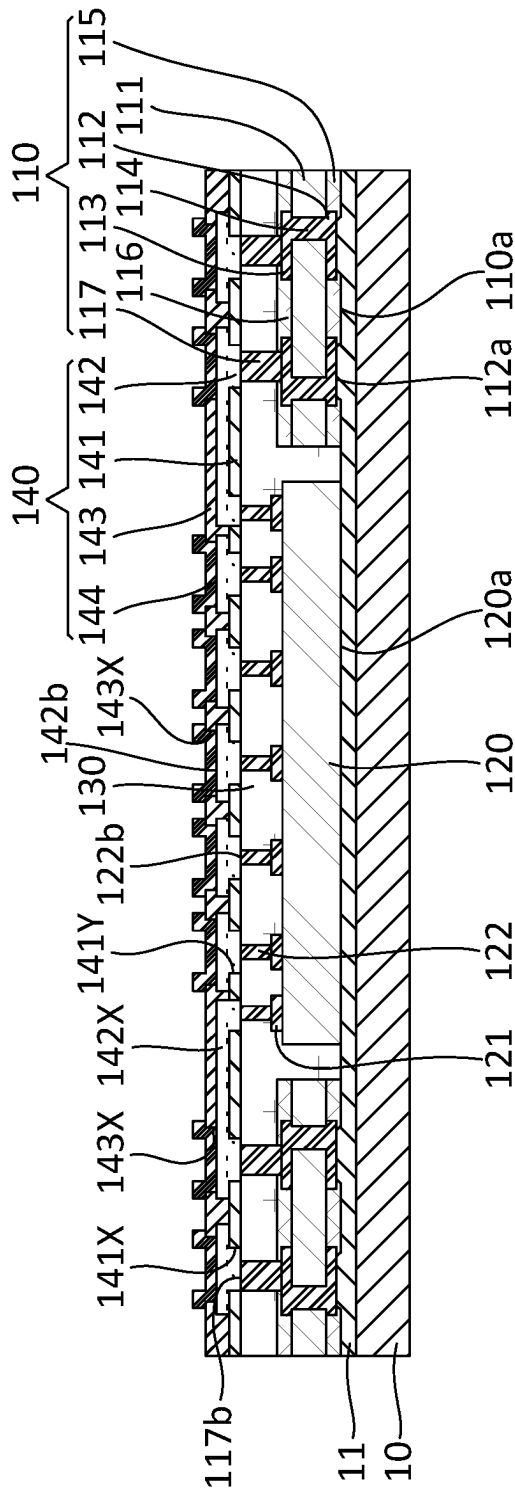


FIG. 2E

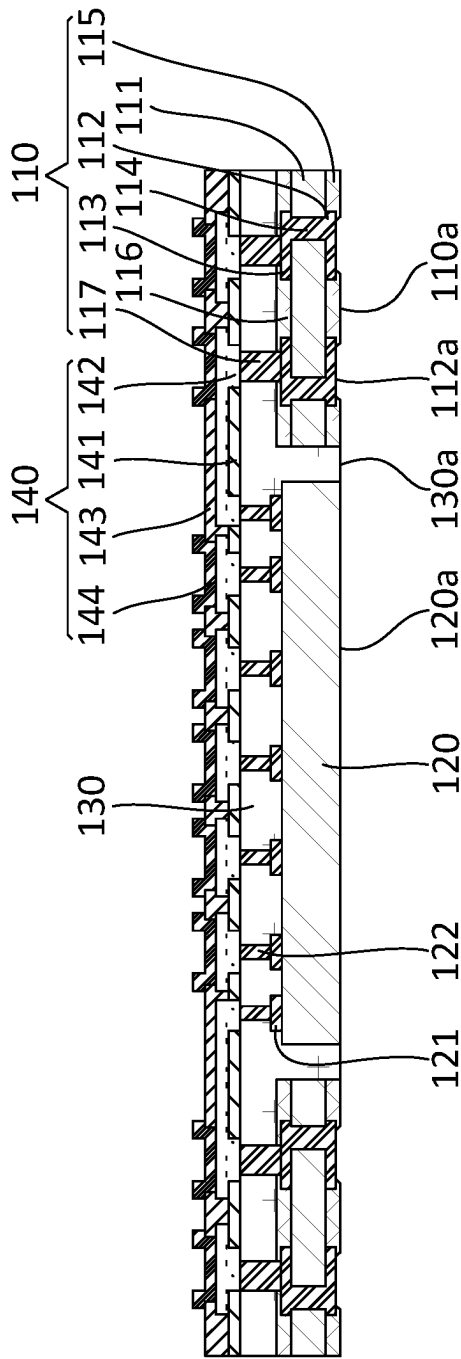


FIG. 2F

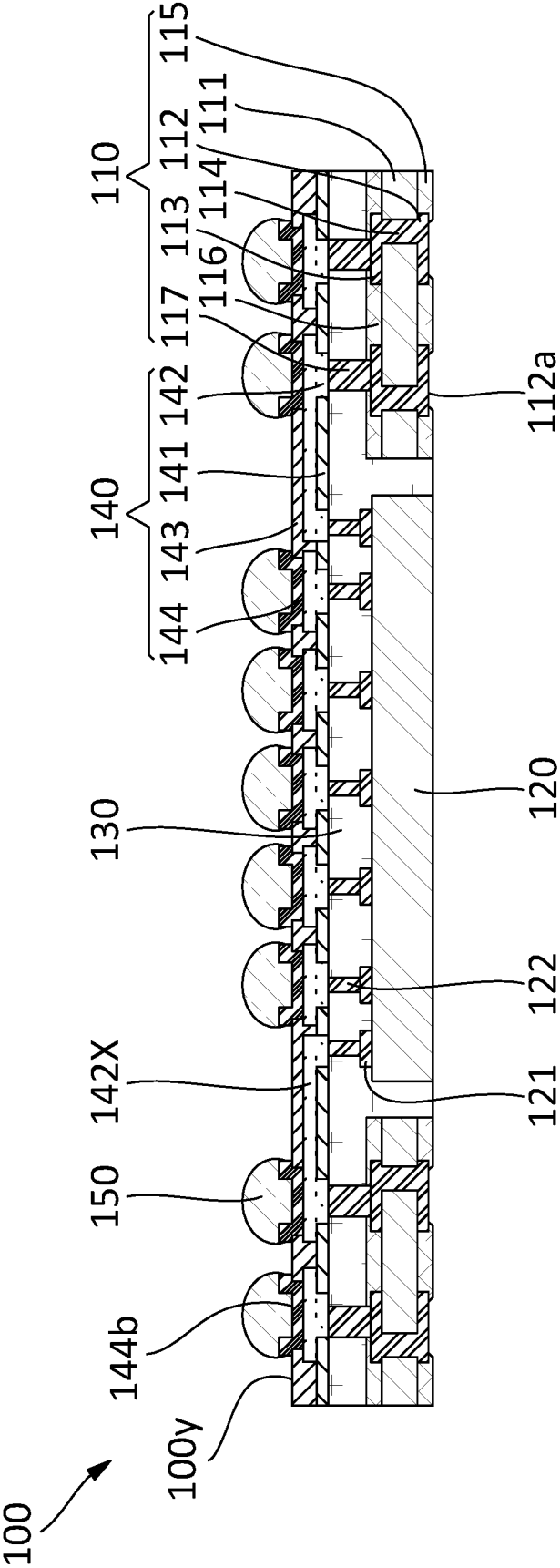
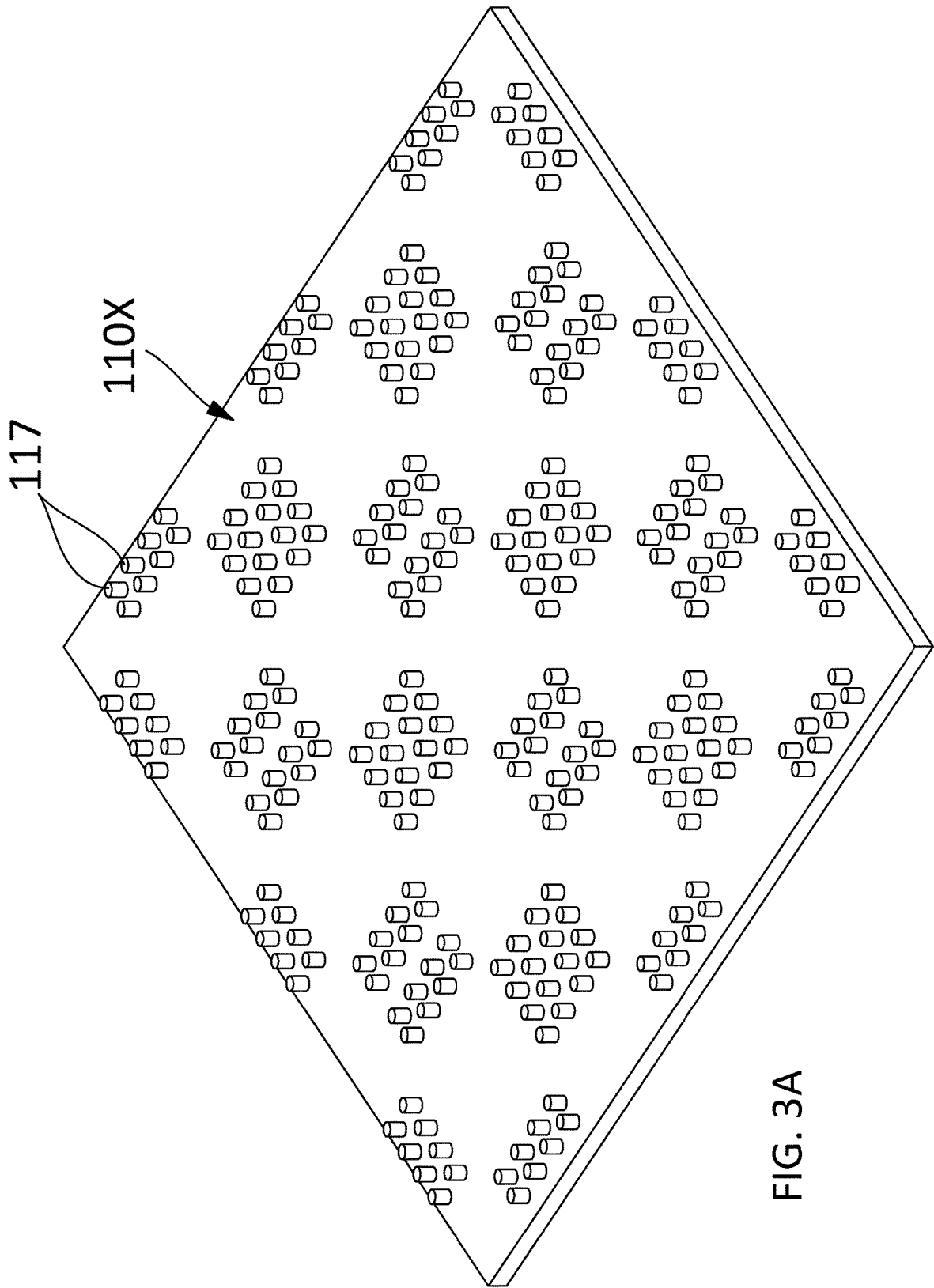
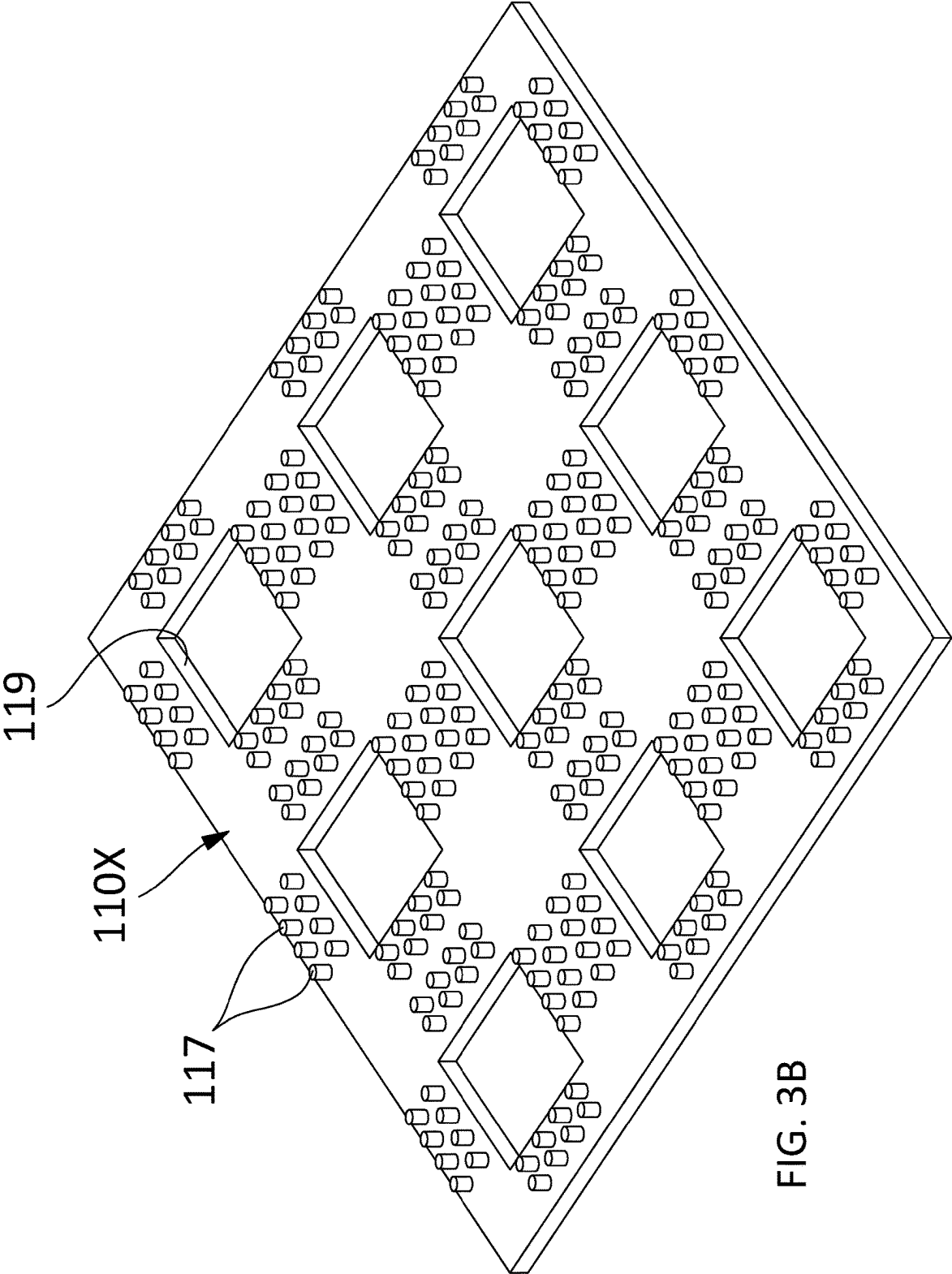


FIG. 2G







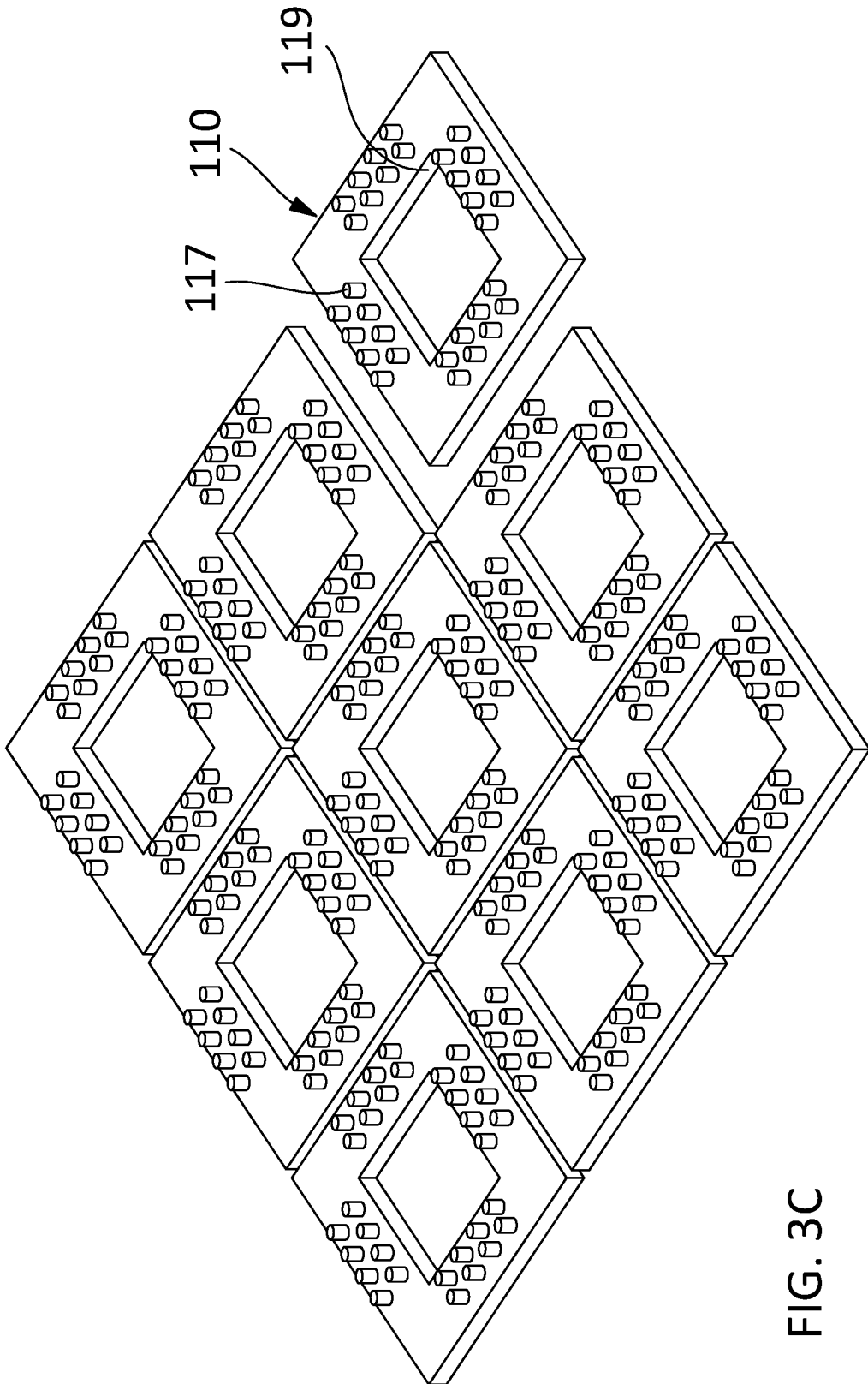


FIG. 3C

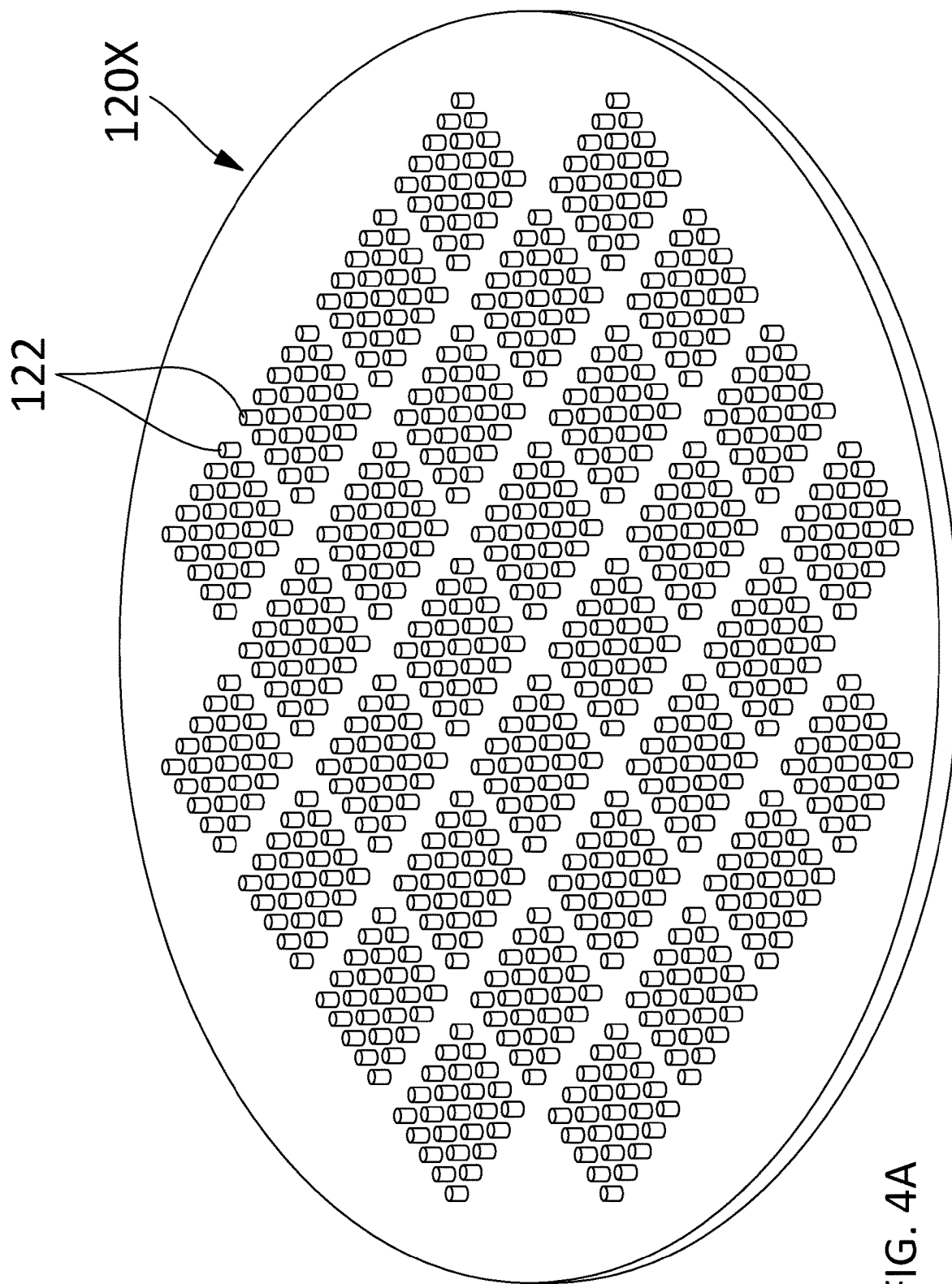


FIG. 4A

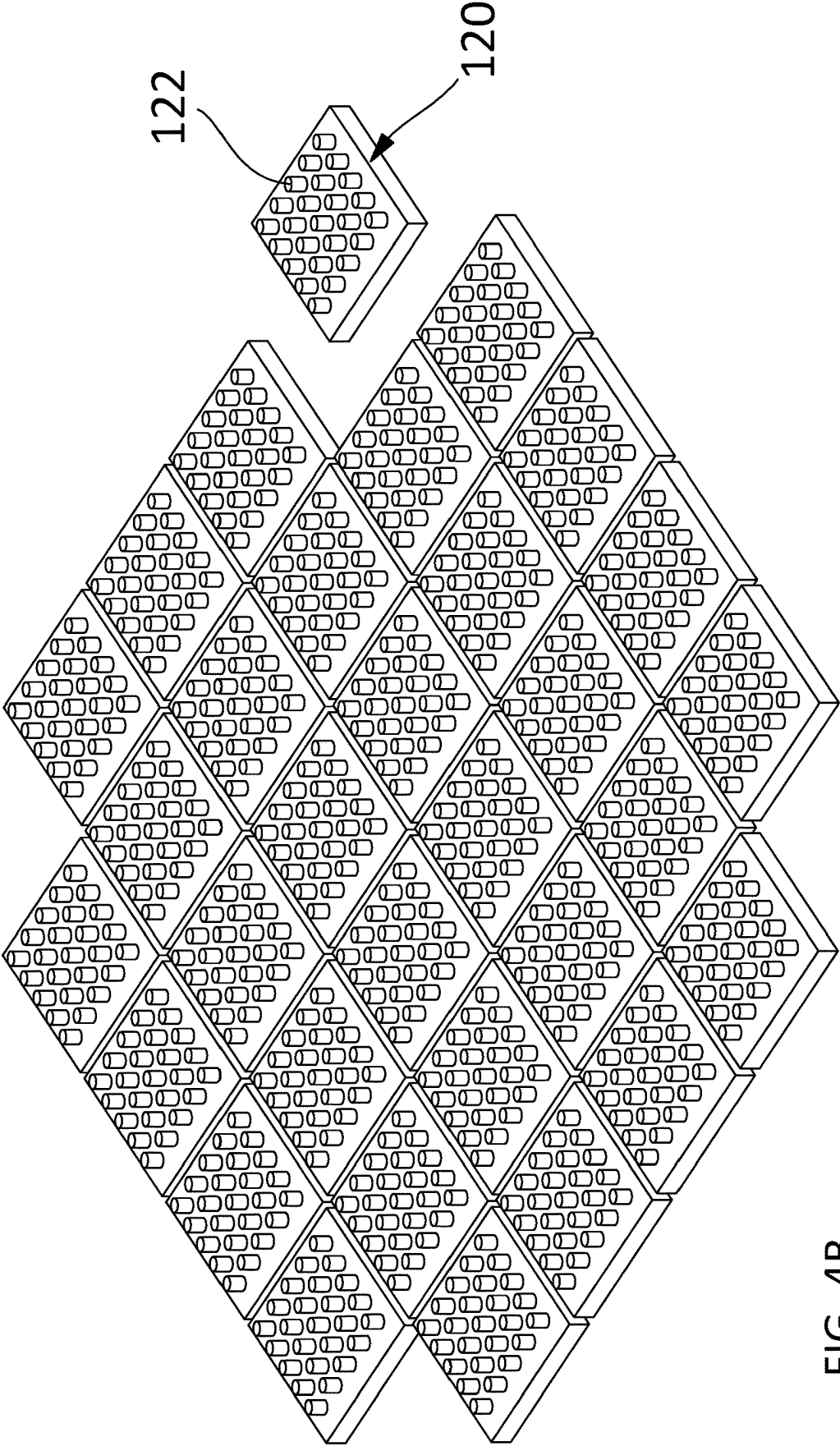


FIG. 4B

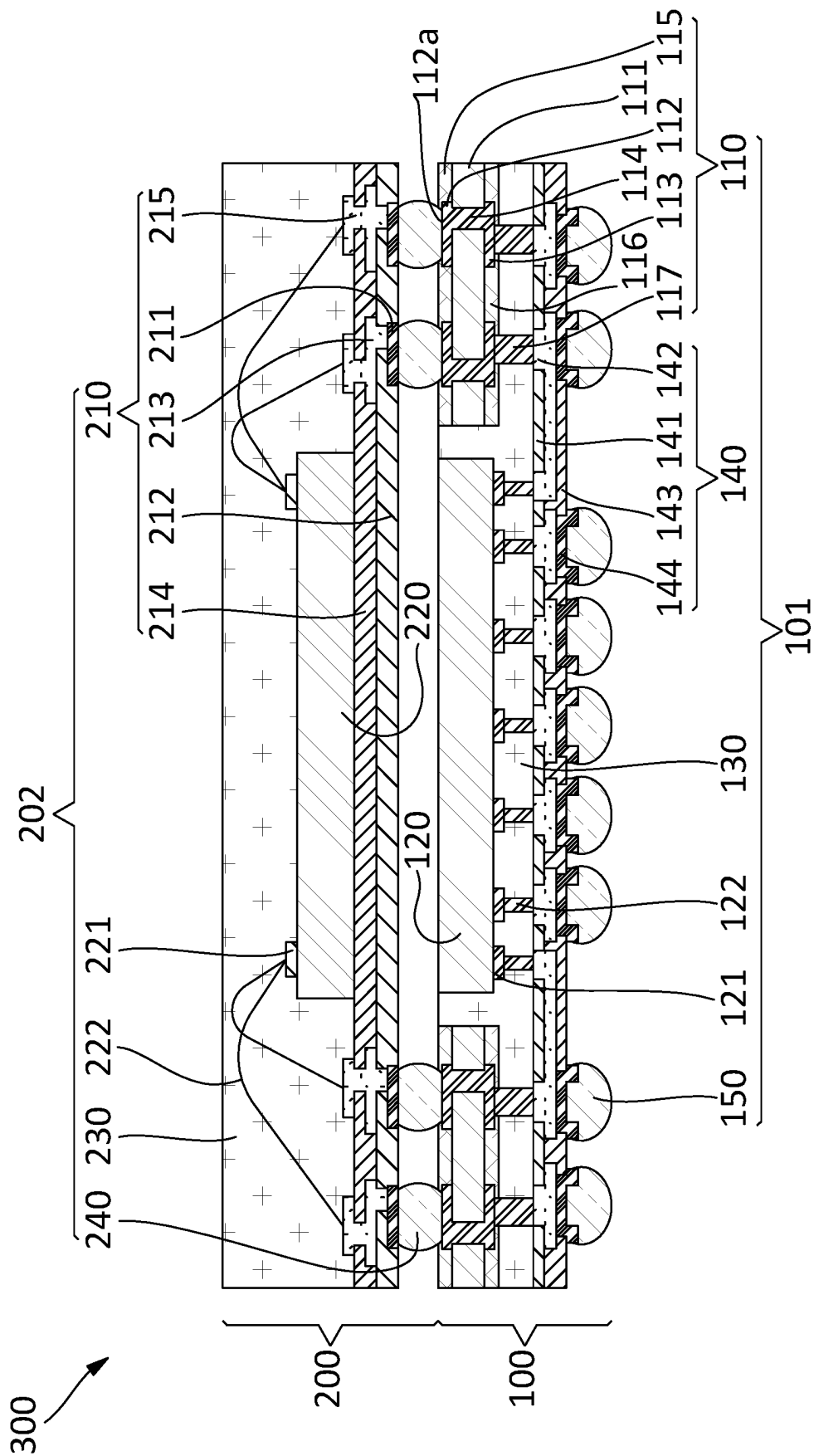


FIG. 5

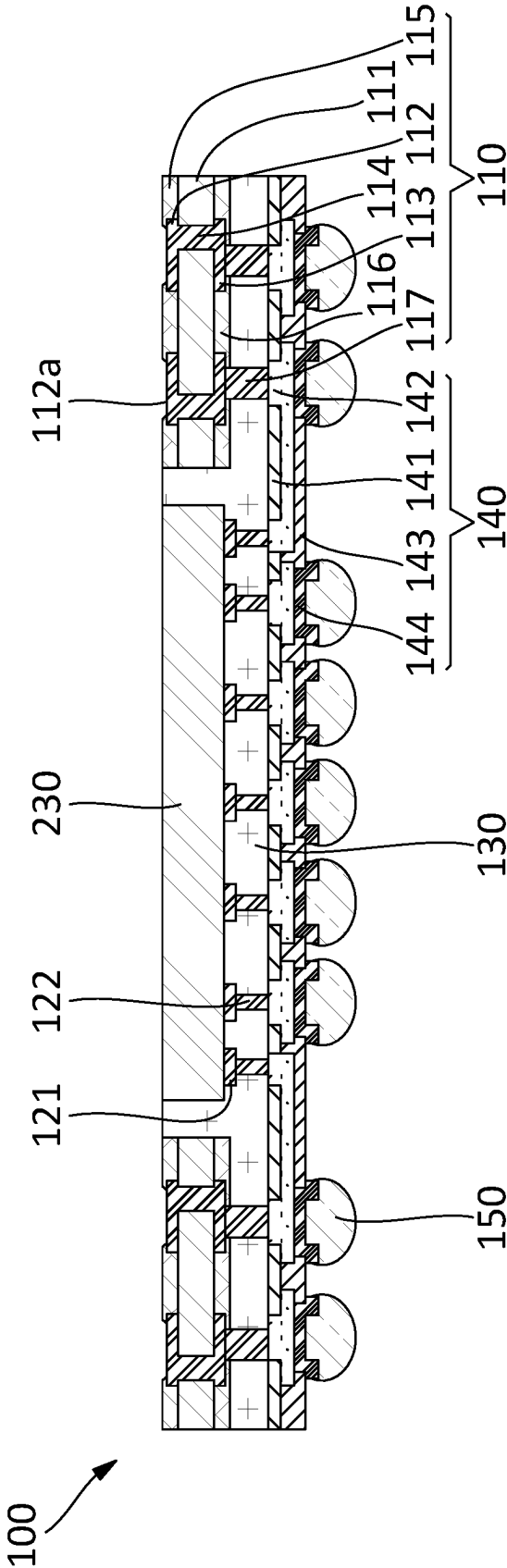


FIG. 6A

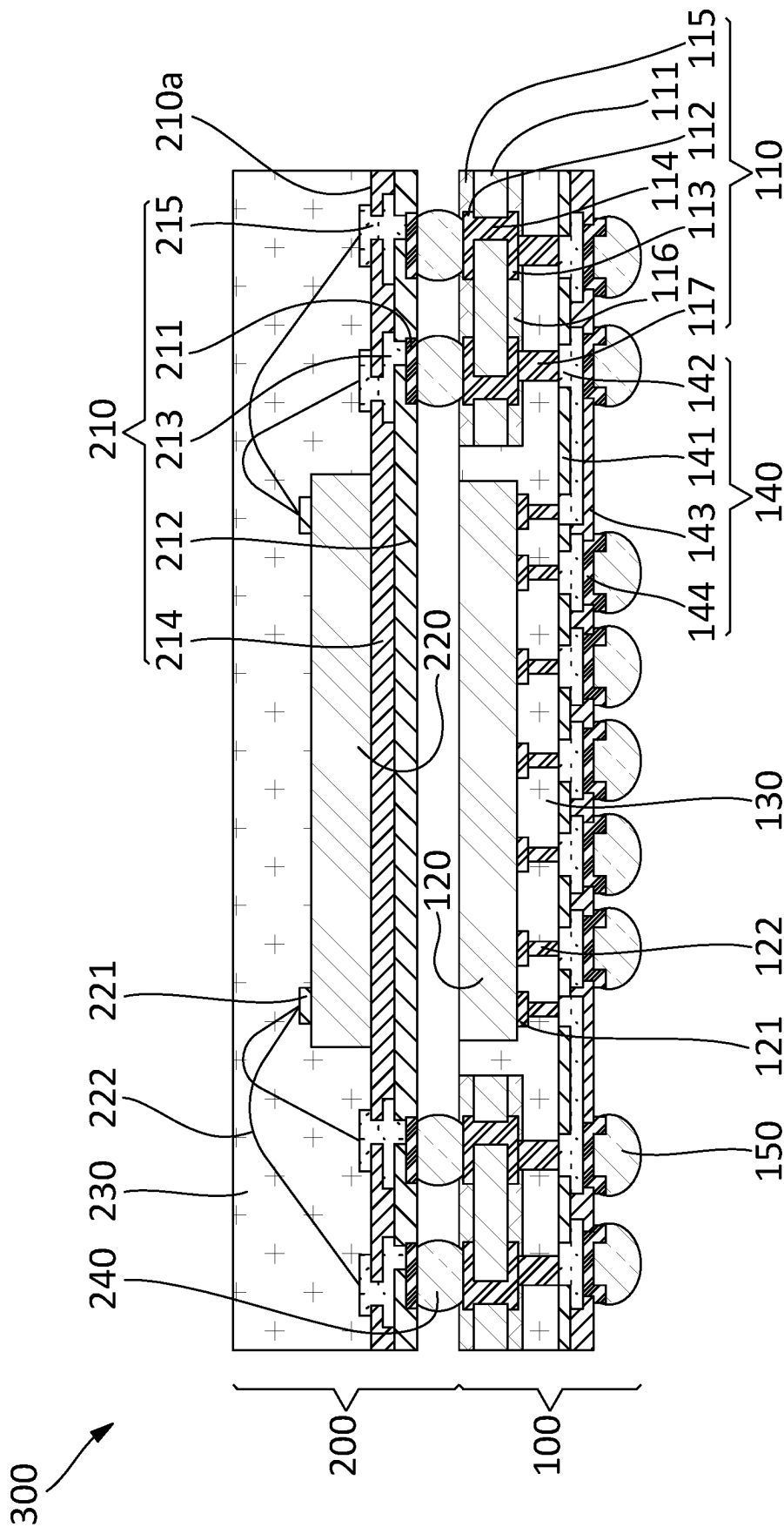


FIG. 6B

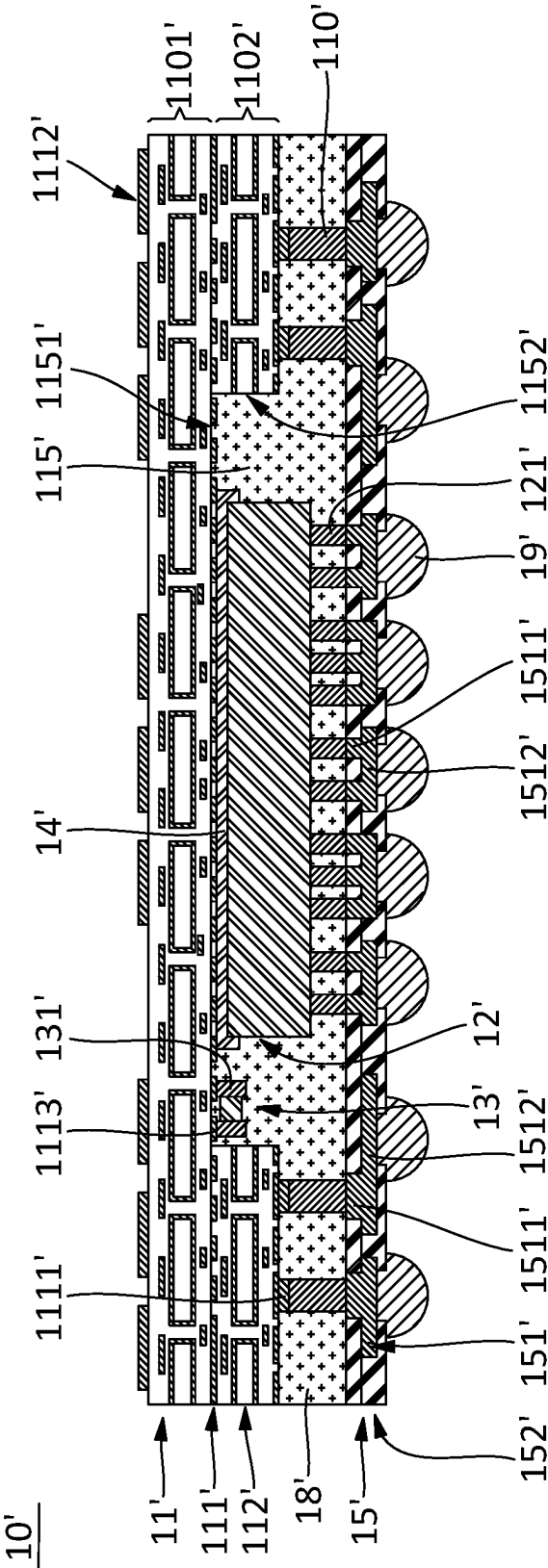


FIG.7



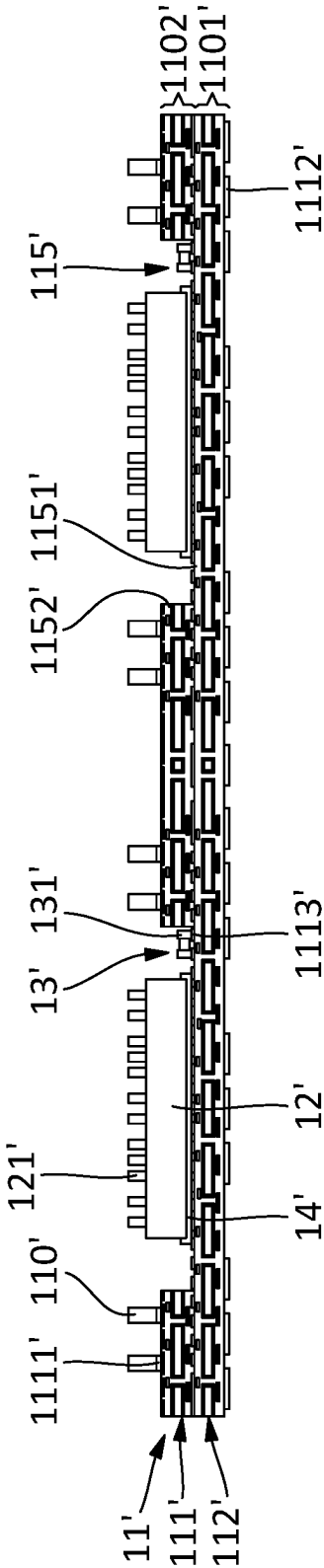


FIG. 8A

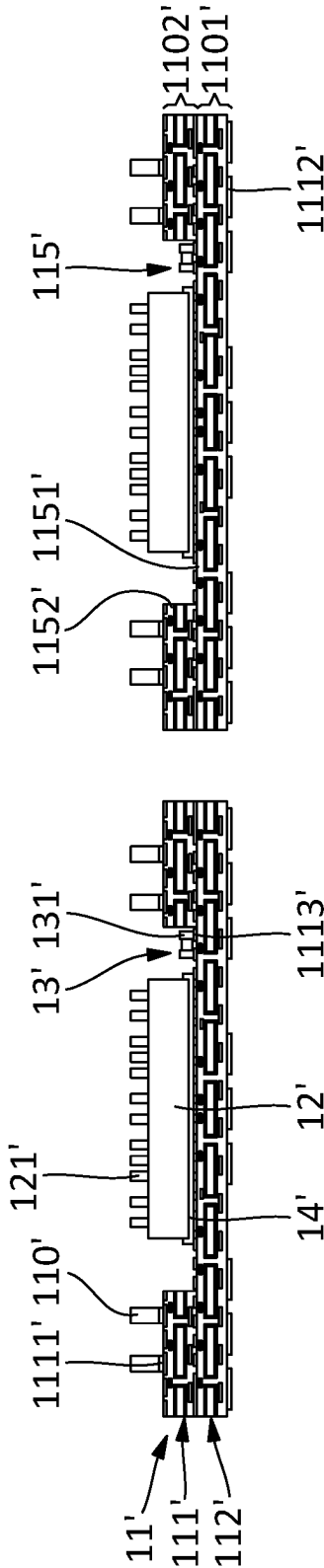
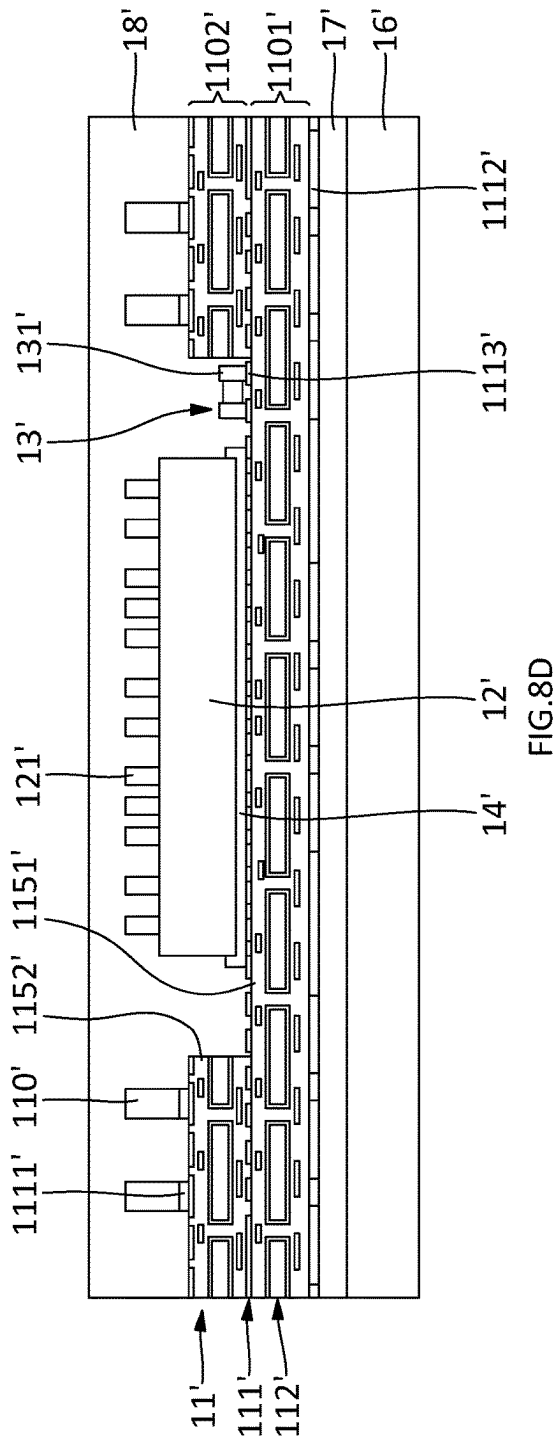
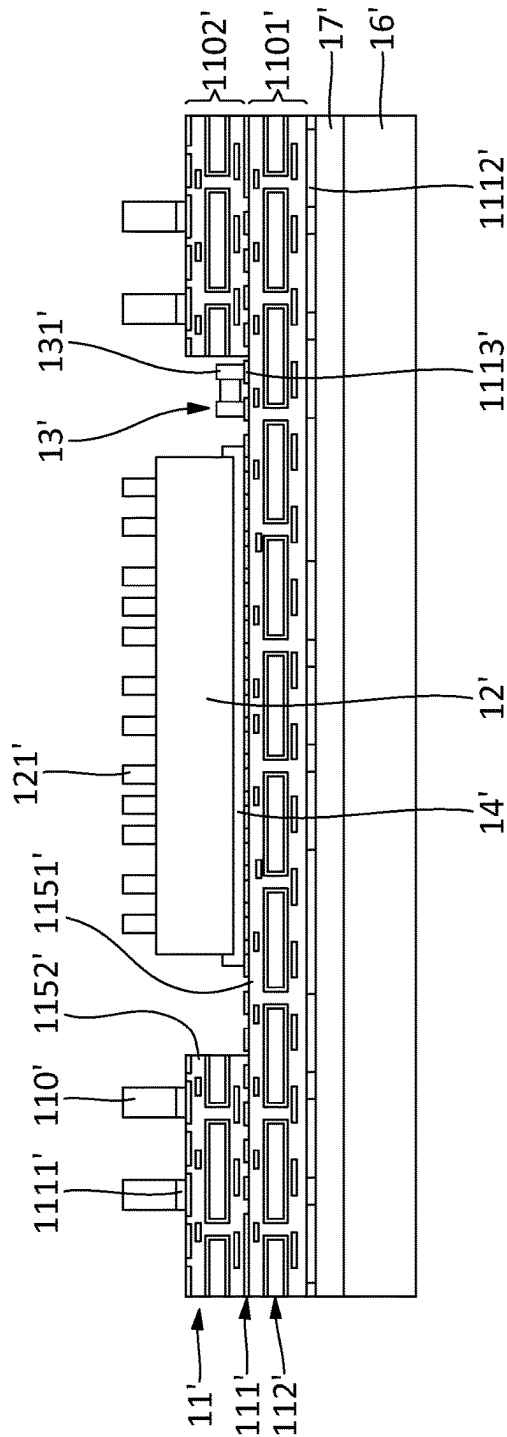


FIG. 8B



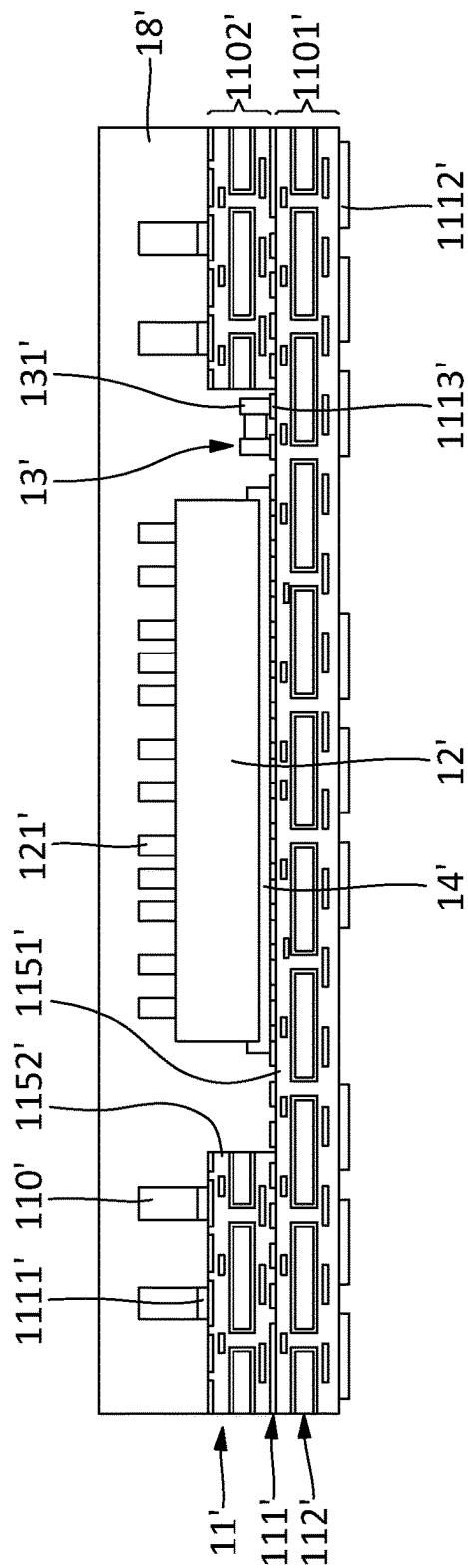


FIG. 8E

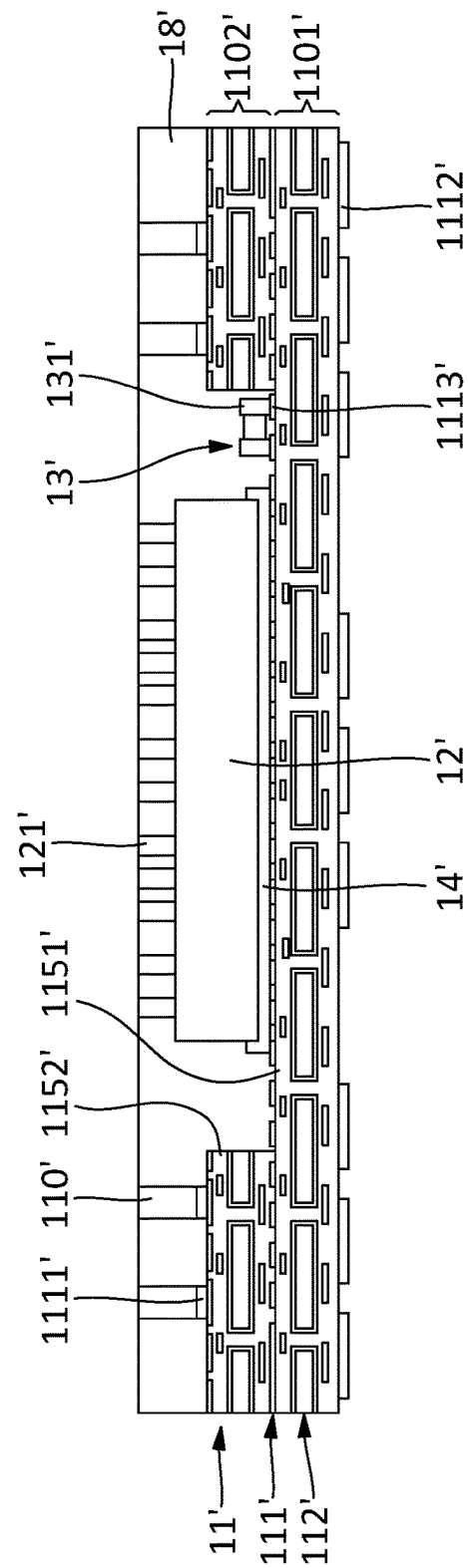
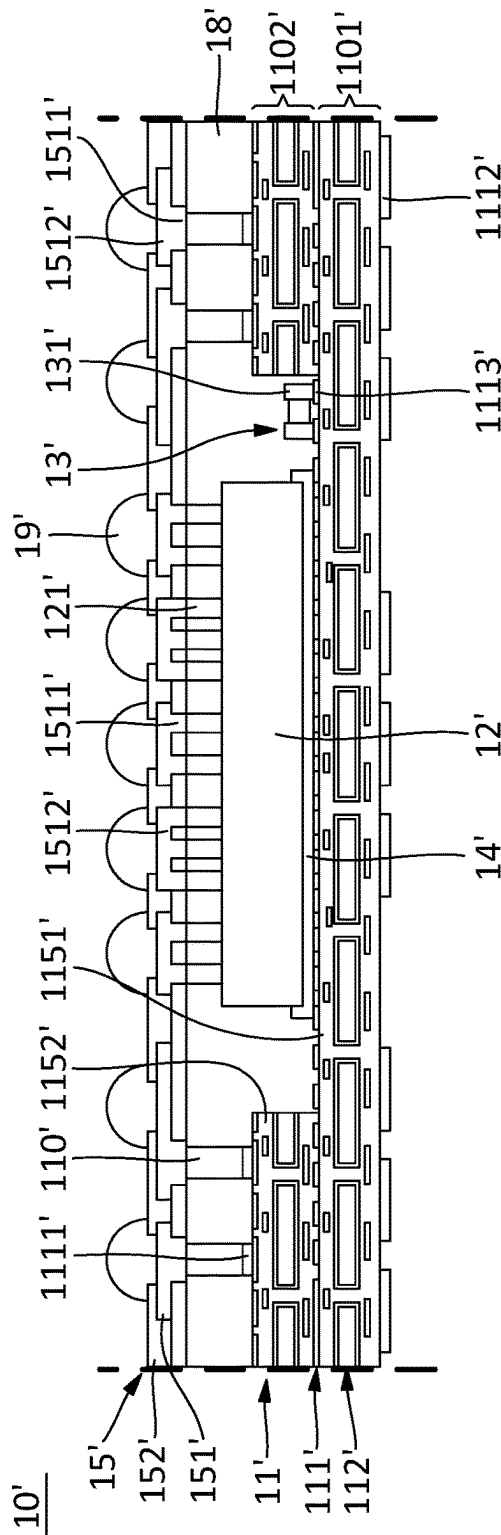
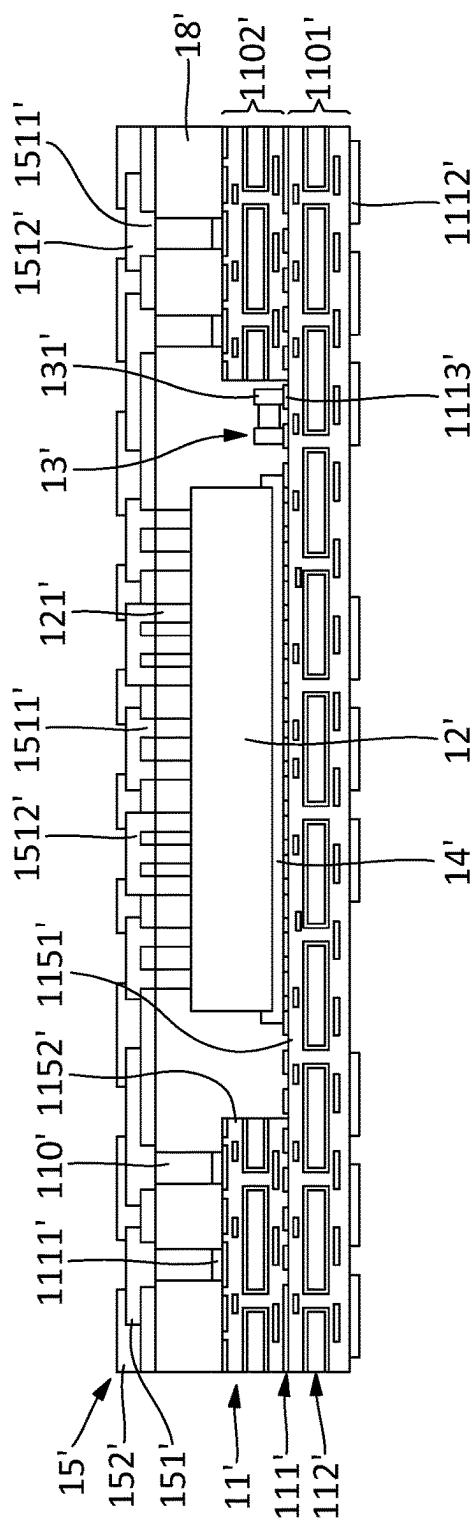


FIG. 8F



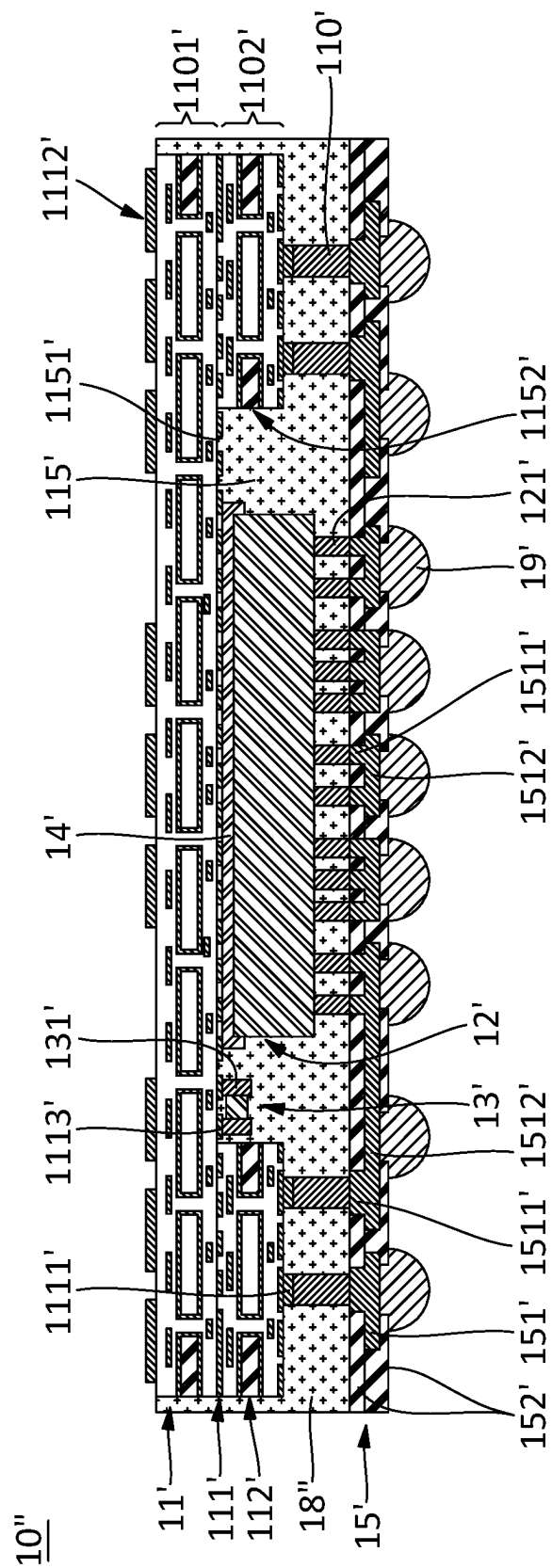


FIG. 9

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# SEMICONDUCTOR DEVICE AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE

## CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in part of U.S. application Ser. No. 17/521,750 filed Nov. 8, 2021 (pending), which is a continuation of U.S. application Ser. No. 16/530,305 filed Aug. 2, 2019, now U.S. Pat. No. 11,171,127. Said application Ser. Nos. 17/521,750 and 16/530,305 and said U.S. Pat. No. 11,171,127 are hereby incorporated herein by reference in their entireties.

## TECHNICAL FIELD

The present disclosure relates, in general, to electronic devices, and more particularly, to semiconductor devices and methods for manufacturing semiconductor devices.

## BACKGROUND

Prior semiconductor packages and methods for forming semiconductor packages are inadequate, for example resulting in excess cost, decreased reliability, relatively low performance, or package sizes that are too large. Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such approaches with the present disclosure and reference to the drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a cross-sectional view of an example semiconductor device.

FIG. 2A to FIG. 2G show cross-sectional views of an example method for manufacturing an example semiconductor device.

FIG. 3A to FIG. 3C show perspective views of an example method for forming a substrate.

FIG. 4A and FIG. 4B show perspective views of an example method for forming an electronic component.

FIG. 5 shows a cross-sectional view of an example semiconductor device.

FIG. 6A and FIG. 6B show cross-sectional views of an example method for manufacturing an example semiconductor device.

FIG. 7 shows a cross-sectional view of an example electronic device.

FIG. 8A to FIG. 8H show cross-sectional views of an example method for manufacturing an example electronic device.

FIG. 9 shows a cross-sectional view of an example electronic device.

The following discussion provides various examples of semiconductor devices and methods of manufacturing semiconductor devices. Such examples are non-limiting, and the scope of the appended claims should not be limited to the particular examples disclosed. In the following discussion, the terms “example” and “e.g.” are non-limiting.

The figures illustrate the general manner of construction, and descriptions and details of well-known features and techniques may be omitted to avoid unnecessarily obscuring the present disclosure. In addition, elements in the drawing figures are not necessarily drawn to scale. For example, the dimensions of some of the elements in the figures may be

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exaggerated relative to other elements to help improve understanding of the examples discussed in the present disclosure. The same reference numerals in different figures denote the same elements.

The term “or” means any one or more of the items in the list joined by “or”. As an example, “x or y” means any element of the three-element set  $\{(x), (y), (x, y)\}$ . As another example, “x, y, or z” means any element of the seven-element set  $\{(x), (y), (z), (x, y), (x, z), (y, z), (x, y, z)\}$ .

The terms “comprises,” “comprising,” “includes,” and/or “including,” are “open ended” terms and specify the presence of stated features, but do not preclude the presence or addition of one or more other features. The terms “first,” “second,” etc. may be used herein to describe various elements, and these elements should not be limited by these terms. These terms are only used to distinguish one element from another. Thus, for example, a first element discussed in this disclosure could be termed a second element without departing from the teachings of the present disclosure.

Unless specified otherwise, the term “coupled” may be used to describe two elements directly contacting each other or describe two elements indirectly connected by one or more other elements. For example, if element A is coupled to element B, then element A can be directly contacting element B or indirectly connected to element B by an intervening element C. Similarly, the terms “over” or “on” may be used to describe two elements directly contacting each other or describe two elements indirectly connected by one or more other elements. Geometrical descriptive terms, such as coplanar, planar, perpendicular, vertical, horizontal, among others, encompass not only such exact terms, but also substantial approximations of such terms, for example, within manufacturing tolerances.

## DESCRIPTION

In one example, a semiconductor structure comprises a redistribution structure comprising a conductive structure, a cavity substrate on a top side of the redistribution structure and having a cavity and a pillar contacting the redistribution structure, an electronic component on the top surface of the redistribution structure and in the cavity, wherein the electronic component is electrically coupled with the conductive structure, and an encapsulant in the cavity and on the top side of the redistribution structure, contacting a lateral side of the electronic component, a lateral side of the cavity, and a lateral side of the pillar.

In another example, a method to manufacture a semiconductor structure comprises providing a cavity substrate having a cavity and a substrate interconnect, placing an electronic component having a component interconnect in the cavity of the cavity substrate, providing an encapsulant in the cavity on a top side of the cavity substrate and contacting a lateral side of the electronic component, the substrate interconnect, and the component interconnect, and providing a redistribution structure on the top side of the cavity substrate, wherein the redistribution structure has a conductive structure coupled with the substrate interconnect.

In a further example, a semiconductor structure comprises a first semiconductor device comprising a redistribution structure comprising a conductive structure, a first substrate on a top side of the redistribution structure and having a cavity and a pillar contacting the redistribution structure, an electronic component on the top surface of the redistribution structure and in the cavity, wherein the electronic component is electrically coupled with the conductive structure via a component interconnect, and an encapsulant in the cavity

and on the top side of the redistribution structure bounding a lateral side of the electronic component and the pillar. The semiconductor structure also comprises a second semiconductor device on a top side of the first semiconductor device, wherein the second semiconductor device is electrically coupled with a substrate land on a top side of the first substrate.

In an additional example, a semiconductor structure comprises a frontside substrate comprising a conductive structure, a backside substrate comprising a base substrate and a cavity substrate contacting the base substrate, wherein the backside substrate is over a top side of the frontside substrate and has a cavity and an internal interconnect contacting the frontside substrate, and a first electronic component over the top side of the frontside substrate and in the cavity. The first electronic component is coupled with the conductive structure, and an encapsulant is in the cavity and on the top side of the frontside substrate, contacting a lateral side of the first electronic component, a lateral side of the cavity, and a lateral side of the internal interconnect. Other examples and related methods are also disclosed herein.

In another example, a method to manufacture a semiconductor structure comprises providing a backside substrate having a cavity and an internal interconnect, wherein the backside substrate comprises a base substrate and a cavity substrate contacting the base substrate, placing an electronic component having a component terminal in the cavity of the backside substrate, providing an encapsulant in the cavity on a top side of the backside substrate and contacting a lateral side of the electronic component, the internal interconnect, and the component terminal, and providing a frontside substrate over the top side of the backside substrate, wherein the frontside substrate has a conductive structure coupled with the internal interconnect.

In yet another example, a semiconductor structure comprises a first semiconductor device and a second semiconductor device over a top side of the first semiconductor device. The first semiconductor device comprises a frontside substrate comprising a conductive structure, a backside substrate comprising a base substrate and a cavity substrate adjacent to the base substrate, wherein the backside substrate is over a top side of the frontside substrate and has a cavity and an internal interconnect contacting the frontside substrate, a first electronic component over the top side of the frontside substrate and in the cavity, wherein the first electronic component is coupled with the conductive structure via a component terminal, and an encapsulant in the cavity and on the top side of the frontside substrate bounding a lateral side of the first electronic component and the internal interconnect. The second semiconductor device is coupled with a substrate land on a top side of the backside substrate.

Other examples are included in the present disclosure. Such examples may be found in the figures, in the claims, and/or in the description of the present disclosure.

FIG. 1 shows a cross-sectional view of an example semiconductor device. In the example shown in FIG. 1, semiconductor device 100 can comprise substrate 110, electronic component 120, encapsulant 130, redistribution structure 140 and external interconnects 150.

Substrate 110 can comprise insulation layer 111, conductive pads 112 and 113, conductive path 114, dielectric layers 115 and 116 and substrate interconnects 117. Electronic component 120 can comprise component interconnects 122. Redistribution structure 140 can comprise dielectric structures 141 and 143 and conductive structures 142 and 144.

Substrate 110, encapsulant 130, redistribution structure 140 and external interconnects 150 can comprise or be

referred to as semiconductor package 101 or package 101, and semiconductor package 101 can provide protection for electronic component 120 from external elements and/or environmental exposure. In addition, semiconductor package 101 can provide electrical coupling between an external component and electronic component 120.

In some examples, the top side of electronic component 120 can be coplanar with the top side of encapsulant 130. In some examples, coplanar can mean that the top side of electronic component 120 can generally lie in the same plane as the top side of encapsulant 130 within manufacturing tolerance. For instance, the top side of electronic component 120 can protrude slightly above the top side of encapsulant 130, or the top side of electronic component 120 can be recessed slightly with respect to the top side of encapsulant 130, while remaining coplanar within such tolerance. It should be noted that these are merely examples describing the relationship between the top side of electronic component and the top side of encapsulant 130, and the scope of the disclosure is not limited in these respects.

In some examples, redistribution structure 140 can comprise a conductive structure 142 or 144, and substrate 110 can comprise a cavity substrate on a top side of redistribution structure 140 having a cavity 119 filled with encapsulant 130 and a pillar 117 contacting redistribution structure 140. Electronic component 120 can be on the top surface of redistribution structure 140 and in the cavity 119, wherein the electronic component 120 is electrically coupled with conductive structure 142 or 144. The encapsulant can be in the cavity 119 and on the top side of 140 redistribution structure, contacting a lateral side of the electronic component 120, a lateral side of the cavity 119, and a lateral side of the pillar 117.

FIGS. 2A to 2G show cross-sectional views of an example method for manufacturing an example semiconductor device 100. FIGS. 3A to 3C show perspective views of an example method for forming substrate 110 shown in FIG. 2A. FIGS. 4A and 4B show perspective views of an example method for forming electronic component 120 shown in FIG. 2B.

FIG. 2A shows a cross-sectional view of semiconductor device 100 at an early stage of manufacture. FIG. 3A to FIG. 3C show perspective views of an example method for forming substrate 110.

In the example shown in FIG. 2A, a carrier 10 can be a substantially planar plate. In some examples, carrier 10 can comprise or be referred to as a board, a wafer, a panel, or a strip. In some examples, carrier 10 can comprise, for example, but is not limited to, steel, stainless steel, aluminum, copper, ceramic, glass, semiconductor, or a wafer. Carrier 10 can have a thickness in the range from approximately 1 millimeter (mm) to approximately 1.5 mm and a width in the range from approximately 200 mm to approximately 320 mm.

Carrier 10 can function to handle multiple components in an integrated manner for attaching substrate 110 to electronic component 120, forming encapsulant 130, and forming redistribution structure 140. Carrier 10 can be commonly applied to different examples disclosed in the present disclosure. Electronic component 120 can have a component interconnect 122 and can be placed in the cavity 119 of the cavity substrate 110. An encapsulant 130 can be provided in the cavity 119 on the top side of the cavity substrate 110 wherein the encapsulant 130 can contact a lateral side of the electronic component 120, a lateral side of the substrate interconnect 117, and a lateral side of the component interconnect 122. Redistribution structure 140 can then be pro-

vided on the top side of the cavity substrate **110**. Redistribution structure **140** can have a conductive structure **144** or **144** coupled with the substrate interconnect **117**.

Temporary bond layer **11** can be provided on a surface of carrier **10**. Temporary bond layer **11** can be provided on the surface of carrier **10** using a coating process such as spin coating, doctor blade, casting, painting, spray coating, slot die coating, curtain coating, slide coating, or knife over edge coating; a printing process, such as screen printing, pad printing, gravure printing, flexographic coating or offset printing; an inkjet printing process; or direct attachment of an adhesive film or an adhesive tape. Temporary bond layer **11** can comprise or be referred to as a temporary adhesive film or a temporary adhesive tape. Temporary bond layer **11** can be, for example, but is not limited to, a thermally releasable film or an ultraviolet (UV) releasable film, which can be weakened in its bonding strength, or can be removed by, heat or UV irradiation. In some examples, temporary bond layer **11** can have a weakened bonding strength or can be removed by physical and/or chemical external forces. Temporary bond layer **11** can have a thickness in the range from approximately 50 micrometers ( $\mu\text{m}$ ) to approximately 100  $\mu\text{m}$ . Temporary bond layer **11** can allow carrier **10** to be separated after the formation of redistribution structure **140** which will later be described. Temporary bond layer **11** can be commonly applied to different examples disclosed in the present disclosure.

Substrate **110** having substrate interconnects **117** and defining cavity **119** can be attached to temporary bond layer **11**. Substrate **110** can comprise insulation layer **111**, conductive pads **112** and **113**, conductive path **114**, dielectric layers **115** and **116** and substrate interconnects **117**. In some examples, at least one of conductive pads **112** and **113**, conductive path **114**, or dielectric layers **115** and **116** can be omitted. In addition, substrate **110** can comprise cavity **119** extending through a region between top surface **110b** and bottom surface **110a**.

In some examples, substrate **110** can comprise or be referred to as a printed circuit board (PCB), a cavity substrate, a printed wiring board, a multi-layered substrate, a through hole substrate, a rigid substrate, a flexible substrate, a glass epoxy substrate, a polyimide substrate, a polyester substrate, a molded plastic substrate, a ceramic substrate, an etched foil process substrate, an additive process substrate, a buildup substrate or a pre-molded lead frame. In some examples, a cavity substrate **110** can be provided having a cavity **119** and a substrate interconnect **117**.

In some examples, insulation layer **111** can have top surface **111b** and bottom surface **111a** that are substantially planar. In some examples, insulation layer **111** can comprise or be referred to as a dielectric layer or a core layer. In some examples, insulation layer **111** can comprise epoxy resin, phenolic resin, glass epoxy, polyimide, polyester, an epoxy molding compound, or silicon resin, or ceramic. In some examples, insulation layer **111** can have a thickness in the range from approximately 10  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ . Insulation layer **111** can maintain substrate **110** at a substantially planar state or can restrict bending, and also can provide insulation between conductors of substrate **110**.

Conductive pads **112** can be formed on bottom surface **111a** of insulation layer **111**, and conductive pads **113** can be formed on top surface **111b** of insulation layer **111**. Conductive pads **112** and **113** can be formed on bottom surface **111a** and top surface **111b** of insulation layer **111** in a matrix configuration having rows and/or columns. In some examples, conductive pads **112** or **113** can comprise or be referred to as conductors, conductive material, substrate

lands, conductive lands, substrate pads, wire pads, connection pads, micro pads, traces, or under-bump-metallurgies (UBMs). In some examples, substrate lands **112** and substrate pads **113** can comprise copper, iron, nickel, gold, silver, palladium, or tin. In some examples, substrate lands **112** and substrate pads **113** can have a thickness, width, and space in the range from approximately 50  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ .

In some examples, conductive path **114** can electrically connect substrate lands **112** and substrate pads **113** while extending through insulation layer **111**. In some examples, conductive path **114** can comprise or be referred to as a conductor, a conductive material, a conductive via, a circuit pattern, or a conductive post. In some examples, conductive path **114** can comprise copper, iron, nickel, gold, silver, palladium, or tin. In some examples, conductive path **114** can have a thickness in the range from approximately 10  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ .

As shown in FIG. 2A and FIG. 2B, dielectric layer **115** can roughly cover portions of substrate lands **112** and bottom surface **111a** of insulation layer **111**, and dielectric layer **116** can roughly cover portions of substrate pads **113** and top surface **111b** of insulation layer **111**. In some examples, dielectric layers **115** and **116** can comprise or be referred to as dielectrics, dielectric materials, dielectric layers, insulation layers, solder masks, or solder resists. In some examples, portions of substrate lands **112** to be connected to another semiconductor device can be exposed through dielectric layer **115**. In addition, portions of substrate pads **113** to be connected to substrate interconnects **117** can be exposed through dielectric layer **116**. In some examples, dielectric layers **115** and **116** can comprise polymer, polyimide (PI), benzocyclobutene (BCB), polybenzoxazole (PBO), bismaleimide triazine (BT), a molding material, a phenolic resin, an epoxy, silicone, or an acrylate polymer. In some examples, dielectric layers **115** and **116** can have a thickness in the range from approximately 10  $\mu\text{m}$  to approximately 100  $\mu\text{m}$ . Dielectric layer **115** can serve to protect conductors proximate to bottom surface **110a** of substrate **110**, and dielectric layer **116** can serve to protect conductors proximate to top surface **110b** of substrate **110**.

FIG. 2A and FIG. 3A show an example method for forming or providing substrate interconnects **117** on substrate **110X**. Substrate **110X** can be used for manufacturing a multitude of individual substrates **110** having a multitude of substrate interconnects **117** and a multitude of cavities **119** at a time.

In the example shown in FIG. 2A and FIG. 3A, substrate **110**, including insulation layer **111**, substrate lands **112**, substrate pads **113**, conductive path **114** and dielectric layers **115** and **116**, can have substrate interconnects **117** electrically connected to substrate pads **113**.

Substrate interconnects **117** can be formed on top surfaces of substrate pads **113**. Like substrate pads **113**, substrate interconnects **117** can be formed in a matrix configuration having rows or columns. Substrate interconnects **117** can be formed to upwardly extend from substrate pads **113**. In some examples, substrate interconnects **117** can have a height in the range from approximately 0.1 mm to approximately 0.5 mm and a width in the range from approximately 0.2 mm to approximately 1 mm.

In some examples, substrate interconnects **117** can be formed by, but not limited to, electroplating, electroless plating, sputtering, PVD, CVD, MOCVD, ALD, LPCVD, or PECVD. In some examples, substrate interconnects **117** can comprise copper, gold, silver, palladium, nickel, or solder. Substrate interconnects **117** can comprise or be referred to as



pillars, posts, columns, vias, vertical wires, bumps, or conductive paths. In some examples, substrate interconnects 117 can electrically and mechanically connect redistribution structure 140 to be described later to substrate 110.

FIG. 2A and FIG. 3B show an example method for forming cavities 119 on substrate 110X. In the example shown in FIG. 2A and FIG. 3B, cavities 119 extending through top surface 110b and bottom surface 110a of substrate 110X can be formed on substrate 110X. Cavities 119 can be formed in a matrix configuration having rows or columns. Cavities 119 can be formed in a rectangular shape or a shape to correspond to electronic component 120. Cavities 119 can be formed in regions including insulation layer 111 and dielectric layers 115 and 116 in substrate 110X. Substrate interconnects 117 can be positioned on top surface 110b of substrate 110X so as to be spaced apart from one another in row and column directions around cavities 119. In some examples, cavities 119 can have a size in the range from approximately 1 mm to approximately 10 mm.

FIGS. 2A and 3C show an example method for singulating substrate 110X into individual substrates 110 each having a cavity 119. In some examples, substrate 110X can be singulated into individual substrates 110 using a diamond blade or laser beam. Bottom surface 110a of each of individual substrates 110 having one cavity 119 can be attached to carrier 10 shown in FIG. 2A through temporary bond layer 11. Substrate 110 can have cavity 119 positioned roughly at its center or can be a rectangular ring. In addition, substrate interconnects 117 spaced apart from one another in row or column directions can be positioned outside the respective sides of cavity 119 formed on top surface of substrate 110.

FIG. 2B shows a cross-sectional view of semiconductor device 100 at a later stage of manufacture. FIG. 4A and FIG. 4B show perspective views of an example method for forming or providing electronic component 120. In the example shown in FIG. 2B, electronic component 120 having component interconnects 122 can be attached to temporary bond layer 11 of carrier 10. A multitude of terminals 121 can be provided on a top surface of electronic component 120, and component interconnects 122 can be electrically connected to multitude of terminals 121, respectively. Terminals 121 can be input/output terminals of electronic component 120 and can comprise or be referred to as die pads or bond pads. In some examples, terminals 121 can have a width in the range from approximately 50  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ .

FIG. 4A shows an example method for forming component interconnects 122 to be electrically connected to terminals 121 of electronic component 120. In the example shown in FIG. 2B and FIG. 4A, wafer 120X having electronic components 120 can be prepared, and component interconnects 122 can be formed on a top surface of wafer 120X to be electrically connected to terminals 121 of electronic components 120. Component interconnects 122 can be formed on top surfaces of terminals 121, respectively. In addition, component interconnects 122 can be formed during fabrication of wafer 120X.

Like terminals 121, component interconnects 122 can be formed in a matrix configuration having rows or columns. Component interconnects 122 can be formed to upwardly extend from terminals 121. In some examples, component interconnects 122 can have a height in the range from approximately 20  $\mu\text{m}$  to approximately 150  $\mu\text{m}$  and a width in the range from approximately 0.05 mm to approximately 1 mm. Component interconnects 122 are formed or provided

during fabrication of wafer 120X, and sizes and widths of component interconnects 122 can be smaller than those of substrate interconnects 117.

In some examples, component interconnects 122 can be formed by, but not limited to, electroplating, electroless plating, sputtering, PVD, CVD, MOCVD, ALD, LPCVD, or PECVD. In some examples, component interconnects 122 can comprise copper, gold, silver, palladium, nickel, or solder. Component interconnects 122 can comprise or be referred to as pillars, posts, columns, bumps, or conductive paths. In some examples, component interconnects 122 can electrically and mechanically connect redistribution structure 140 to be described later to electronic component 120.

FIG. 4B shows an example method for singulating wafer 120X having component interconnects 122 into individual electronic components 120. In the example shown in FIG. 2B and FIG. 4B, wafer 120X having component interconnects 122 can be singulated into individual electronic components 120. In some examples, wafer 120X can be divided into individual electronic components 120 using a diamond blade or laser beam.

A bottom surface 120a of each of electronic components 120 having component interconnects 122 can be attached to carrier 10 shown in FIG. 2B through temporary bond layer 11. Electronic component 120 can be positioned within cavity 119 of substrate 110. Electronic component 120 can have a smaller size than cavity 119. Side surfaces of electronic component 120 can be spaced apart from substrate 110.

Electronic component 120 can comprise or be referred to as a semiconductor die, a semiconductor chip, or a semiconductor package, such as a chip-scale package. In some examples, electronic component 120 can comprise at least one of an application specific integrated circuit, a logic die, a micro control unit, a memory, a digital signal processor, a network processor, a power management unit, an audio processor, a radio-frequency (RF) circuit, or a wireless baseband system on chip processor. Electronic component 120 can have a thickness in the range from approximately 50  $\mu\text{m}$  to approximately 780  $\mu\text{m}$ . Electronic component 120 can have a size in the range from approximately 3 mm to approximately 10 mm.

FIG. 2C shows a cross-sectional view of semiconductor device 100 at a later stage of manufacture. In the example shown in FIG. 2C, encapsulant 130 can be formed to entirely cover substrate 110 and electronic component 120. In some examples, encapsulant 130 can contact top surface 110b of substrate 110, can fill cavity 119, and contact side surfaces and top surfaces of substrate interconnects 117. In some examples, encapsulant 130 can contact side surfaces of electronic component 120 or can contact both side surfaces and top surfaces of component interconnects 122.

In some examples, encapsulant 130 can comprise or be referred to as an epoxy molding compound, an epoxy resin, a protective dielectric, or a sealant. In addition, in some examples, encapsulant 130 can comprise or be referred to as a molding part, a sealing part, an encapsulation part, a protection part, or a package body. In some examples, encapsulant 130 can comprise, but is not limited to, an organic resin, an inorganic filler, a curing agent, a catalyst, a coupling agent, a colorant, or a flame retardant. Encapsulant 130 can be formed by any of a variety of processes. In some examples, encapsulant 130 can be formed by, but not limited to, compression molding, transfer molding, liquid-phase encapsulant molding, vacuum lamination, paste printing, or film assist molding. Encapsulant 130 can have a thickness in the range from approximately 0.1 mm to

approximately 1 mm. Encapsulant 130 can be formed to cover substrate 110 and electronic component 120 to protect substrate 110 and electronic component 120 from external elements and/or environmental exposure.

FIG. 2D shows a cross-sectional view of semiconductor device 100 at a later stage of manufacture. In the example shown in FIG. 2D, an upper portion of encapsulant 130 can be removed to expose top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component interconnects 122 at top surface 130b of encapsulant 130. Encapsulant 130 can be removed by grinding or chemical etching. Upper portions of substrate interconnects 117 and upper portions of component interconnects 122 can also be removed. Top surface 130b of encapsulant 130 can be coplanar with top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component interconnects 122. Encapsulant 130 having its upper portion removed can have a thickness in the range from approximately 10  $\mu\text{m}$  to approximately 100  $\mu\text{m}$ .

FIG. 2E shows a cross-sectional view of semiconductor device 100 at a later stage of manufacture. In the example shown in FIG. 2E, redistribution structure 140 can be formed on top surface 130b of encapsulant 130, top surfaces 117b of substrate interconnects 117, and top surfaces 122b of component interconnects 122. In some examples, redistribution structure 140 can be similar to substrate 110, or can comprise or be referred to as a substrate. Redistribution structure 140 can comprise first dielectric structure 141, first conductive structure 142, second dielectric structure 143, and second conductive structure 144 sequentially formed. In redistribution structure 140, first dielectric structure 141 can be first formed to cover top surface 130b of encapsulant 130, top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component interconnects 122 to a substantially uniform thickness. In addition, apertures 141X and 141Y can be formed in first dielectric structure 141 to expose top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component interconnects 122.

First dielectric structure 141 or second dielectric structure 143 can comprise or be referred to as a dielectric, a dielectric material, a dielectric layer, a passivation layer, an insulation layer or a protection layer. In some examples, first dielectric structure 141 or second dielectric structure 143 can comprise, but are not limited to, an electrically insulating material, such as a polymer, polyimide (PI), benzocyclobutene (BCB), polybenzoxazole (PBO), bismaleimide triazine (BT), a molding material, a phenolic resin, an epoxy, silicone, or an acrylate polymer. In addition, in some examples, first dielectric structure 141 or second dielectric structure 143 can be formed by any of a variety of processes. In some examples, first dielectric structure 141 or second dielectric structure 143 can be formed by spin coating, spray coating, printing, PVD, CVD, MOCVD, ALD, LPCVD, or PECVD. First dielectric structure (i.e., passivation layer) 141 or second dielectric structure 143 can have a thickness in the range from approximately 1  $\mu\text{m}$  to approximately 20  $\mu\text{m}$ .

In some examples, a mask pattern can be formed on a top surface of first dielectric structure 141, and areas of first dielectric structure 141 can then be removed by etching, forming apertures 141X and 141Y. Apertures 141X and 141Y can comprise or be referred to as openings or holes. First dielectric structure 141 can expose top surfaces 117b of substrate interconnects 117 through aperture 141X and can expose top surfaces 122b of component interconnects 122 through aperture 141Y. In some examples, a photoresist can be used as the mask pattern. Top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component

interconnects 122, which are exposed by apertures 141X and 141Y, can have circular, rectangular, or polygonal shapes.

Redistribution structure 140 can have first conductive structure 142 formed to cover top surface of first dielectric structure 141 and top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component interconnects 122, which are exposed by apertures 141X and 141Y.

First conductive structure 142 can be formed with a multitude of conductors, traces, or patterns, and the respective conductors can be brought into contact with top surfaces 117b of substrate interconnects 117, or top surfaces 122b of component interconnects 122, as exposed by apertures 141X and 141Y. Conductors or first conductive structure 142 can be electrically connected to substrate 110 through substrate interconnects 117, or to electronic component 120 through component interconnects 122. First conductive structure 142 can comprise conductors 142X electrically connecting top surfaces 117b of substrate interconnects 117 with top surfaces 122b of component interconnects 122. Conductor 142X can extend from a point over electronic component 120 to a point over substrate 110 and can electrically connect electronic component 120 and substrate 110 to each other.

In some examples, first conductive structure 142 or second conductive structure 144 can comprise or be referred to as a conductor, a conductive material, a conductive layer, a redistribution layer (RDL), a wiring pattern, a trace pattern, or a circuit pattern. In some examples, conductor 142X can comprise or be referred to as a fan-out path, extending both within and past the footprint of electronic component 120. In some examples, first conductive structure 142 or second conductive structure 144 can be made from any of a variety of conductive materials including, for example, copper, gold, silver, or equivalents. First conductive structure 142 or second conductive structure can be formed by any of a variety of processes including, for example, sputtering, electroless plating, electroplating, PVD, CVD, MODVD, ALD, LPCVD, PECVD, or equivalents. First conductive structure 142 can be formed to a predetermined thickness to cover top surface of first dielectric structure 141, top surfaces 117b of substrate interconnects 117 and top surfaces 122b of component interconnects 122, which are exposed by apertures 141X and 141Y, and can be patterned through a mask pattern to define a multitude of conductors. First conductive structure 142 can have a thickness in the range from approximately 5  $\mu\text{m}$  to approximately 50  $\mu\text{m}$ .

Redistribution structure 140 can have second dielectric structure 143 formed to cover first dielectric structure 141 and first conductive structure 142 to a substantially uniform thickness. Apertures 143X exposing top surfaces 142b of first conductive structure 142 can be formed in second dielectric structure 143. Second dielectric structure 143 can also expose top surfaces of conductors 142X through apertures 143X. Second dielectric structure 143 can be similar to first dielectric structure 141 and can be similarly formed as first dielectric structure 141.

Redistribution structure 140 can have second conductive structure 144 formed to cover top surfaces 142b of first conductive structure 142 exposed through apertures 143X. Second conductive structure 144 can be formed with a multitude of conductors, traces, or patterns, and the respective conductors can be brought into contact with top surface 142b of first conductive structure 142 as exposed by aperture 143X. Second conductive structure 144 can be formed to partially cover a top surface of second dielectric structure 143. Second conductive structure 144 can be electrically connected to substrate interconnects 117 and/or component interconnects 122 through first conductive structure 142.

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Second conductive structure **144** can comprise or be referred to as a conductor, a conductive material, a conductive layer, a conductive pad, a micro pad, a bond pad, a conductive post or an under-bump-metallurgy (UBM). Second conductive structure **144** can be similar to first conductive structure **142** and can be similarly formed as first conductive structure **142**. Redistribution structure **140** comprising two dielectric structures **141** and **143** and two conductive structures **142** and **144** is illustrated as an example, but redistribution structure **140** can comprise fewer or more than dielectric structures **141** and **143** or conductive structures **142** and **144**.

Substrate **140** is presented as a redistribution layer ("RDL") substrate in the present example. RDL substrates can comprise one or more conductive redistribution layers and one or more dielectric layers that (a) can be formed layer by layer over an electronic device to which the RDL substrate is to be electrically coupled, or (b) can be formed layer by layer over a carrier that can be entirely removed or at least partially removed after the electronic device and the RDL substrate are coupled together. RDL substrates can be manufactured layer by layer as a wafer-level substrate on a round wafer in a wafer-level process, and/or as a panel-level substrate on a rectangular or square panel carrier in a panel-level process. RDL substrates can be formed in an additive buildup process that can include one or more dielectric layers alternately stacked with one or more conductive layers that define respective conductive redistribution patterns or traces configured to collectively (a) fan-out electrical traces outside the footprint of the electronic device, and/or (b) fan-in electrical traces within the footprint of the electronic device. The conductive patterns can be formed using a plating process such as, for example, an electroplating process or an electroless plating process. The conductive patterns can comprise an electrically conductive material such as, for example, copper or other plateable metal. The locations of the conductive patterns can be made using a photo-patterning process such as, for example, a photolithography process and a photoresist material to form a photolithographic mask. The dielectric layers of the RDL substrate can be patterned with a photo-patterning process, which can include a photolithographic mask through which light is exposed to photo-pattern desired features such as vias in the dielectric layers. The dielectric layers can be made from photo-definable organic dielectric materials such as, for example, polyimide (PI), benzocyclobutene (BCB), or polybenzoxazole (PBO). Such dielectric materials can be spun-on or otherwise coated in liquid form, rather than attached as a pre-formed film. To permit proper formation of desired photo-defined features, such photo-definable dielectric materials can omit structural reinforcements or can be filler-free, without strands, weaves, or other particles, that could interfere with the light from the photo-patterning process. In some examples, such filler-free characteristics of filler-free dielectric materials can permit a reduction of the thickness of the resulting dielectric layer. Although the photo-definable dielectric materials described above can be organic materials, in other examples the dielectric materials of the RDL substrates can comprise one or more inorganic dielectric layers. Some examples of inorganic dielectric layer(s) can comprise silicon nitride ( $\text{Si}_3\text{N}_4$ ), silicon oxide ( $\text{SiO}_2$ ), and/or  $\text{SiON}$ . The inorganic dielectric layer(s) can be formed by growing the inorganic dielectric layers using an oxidation or nitridization process instead using photo-defined organic dielectric materials. Such inorganic dielectric layers can be filler-free, without strands, weaves, or other dissimilar inorganic particles. In some examples, the RDL substrates can omit a permanent core structure or carrier

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such as, for example, a dielectric material comprising bismaleimide triazine (BT) or FR4 and these types of RDL substrates can be referred to as a coreless substrate. Other substrates in this disclosure can also comprise an RDL substrate.

In some examples, substrate **140** can be a pre-formed substrate. The pre-formed substrate can be manufactured prior to attachment to an electronic device and can comprise dielectric layers between respective conductive layers. The conductive layers can comprise copper and can be formed using an electroplating process. The dielectric layers can be relatively thicker non-photo-definable layers that can be attached as a pre-formed film rather than as a liquid and can include a resin with fillers such as strands, weaves, and/or other inorganic particles for rigidity and/or structural support. Since the dielectric layers are non-photo-definable, features such as vias or openings can be formed by using a drill or laser. In some examples, the dielectric layers can comprise a prepreg material or Ajinomoto Buildup Film (ABF). The pre-formed substrate can include a permanent core structure or carrier such as, for example, a dielectric material comprising bismaleimide triazine (BT) or FR4, and dielectric and conductive layers can be formed on the permanent core structure. In other examples, the pre-formed substrate can be a coreless substrate which omits the permanent core structure, and the dielectric and conductive layers can be formed on a sacrificial carrier that is removed after formation of the dielectric and conductive layers and before attachment to the electronic device. The pre-formed substrate can be referred to as a printed circuit board (PCB) or a laminate substrate. Such pre-formed substrate can be formed through a semi-additive or modified-semi-additive process. Other substrates in this disclosure can also comprise a pre-formed substrate.

FIG. 2F shows a cross-sectional view of semiconductor device **100** at a later stage of manufacture. In the example shown in FIG. 2F, carrier **10** can be removed from bottom surface **110a** of substrate **110**, bottom surface **120a** of electronic component **120** and bottom surface **130a** of encapsulant **130**. In a state in which temporary bond layer **11** is attached to carrier **10**, carrier **10** can be removed from substrate **110**, electronic component **120**, and encapsulant **130**. In some examples, adhesion of temporary bond layer **11** can be removed or weakened by supplying heat, light, a chemical solution, or a physical external force. Accordingly, bottom surface **110a** of substrate **110**, bottom surface **120a** of electronic component **120**, and bottom surface **130a** of encapsulant **130** can be exposed. In addition, bottom surfaces **112a** of substrate lands **112** can also be exposed.

FIG. 2G shows a cross-sectional view of semiconductor device **100** at a later stage of manufacture. In the example shown in FIG. 2G, external interconnects **150** can be provided on top surface **144b** of second conductive structure **144**. External interconnects **150** can be electrically connected to top surface **144b** of second conductive structure **144**. External interconnects **150** can be electrically connected to substrate **110** through redistribution structure **140** and substrate interconnects **117**, or to electronic component **120** through redistribution structure **140** and component interconnects **122**. In addition, external interconnects **150** can be electrically connected to both substrate **110** and electronic component **120** through conductors **142X** of redistribution structure **140**.

In some examples, external interconnects **150** can comprise tin (Sn), silver (Ag), lead (Pb), copper (Cu), Sn—Pb, Sn37—Pb, Sn95—Pb, Sn—Pb—Ag, Sn—Cu, Sn—Ag, Sn—Au, Sn—Bi, or Sn—Ag—Cu. External interconnects **150**

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can be formed by, for example, ball dropping, screen printing, or electroplating. For example, external interconnects **150** can be formed by forming a conductive material containing solder on top surface **144b** of second conductive structure **144** of redistribution structure **140** by ball dropping, followed by performing a reflow process. External interconnects **150** can comprise or be referred to as conductive balls, such as solder balls, conductive pillars, such as copper pillars, or conductive posts having solder caps formed on copper pillars. External interconnects **150** can have a size in the range from approximately 0.1 mm to approximately 0.5 mm. Additionally, completed semiconductor device **100** can be flipped, and external interconnects **150** can be positioned on bottom surface **100y** of substrate **100** of semiconductor device **100**. In some examples, external interconnects **150** can comprise or be referred to as external input/output terminals of semiconductor device **100**.

Referring now to FIG. 5, a cross-sectional view of an example semiconductor device **300** is shown. In the example shown in FIG. 5, semiconductor device **300** can comprise first semiconductor device **100** and a second semiconductor device **200**. First semiconductor device **100** can be the same with semiconductor device **100** shown in FIG. 1. Second semiconductor device **200** can comprise substrate **210**, electronic component **220**, encapsulant **230**, and interconnects **240**. First semiconductor device **100** can comprise redistribution structure **140** comprising conductive structure **142** or **144**, a first substrate **110** on a top side of redistribution structure **140** and having a cavity **119** and a pillar contacting redistribution structure **140**. Electronic component **120** can be on the top surface of redistribution structure **140** and in the cavity **119**, wherein the electronic component **120** can be electrically coupled with the conductive structure **142** or **144** via a component interconnect **122**. An encapsulant **130** can be in the cavity **119** and on the top side of redistribution structure **140** bounding a lateral side of the electronic component **120** and the pillar **117**.

The second semiconductor device **200** can be on a top side of the first semiconductor device **100**, wherein the second semiconductor device **200** can be electrically coupled with a substrate land **112** on the top side of the first semiconductor device **100**. Referring to the second semiconductor device **200**, substrate **210** can comprise dielectric layers **212** and **214** and conductive layers **211**, **213** and **215**. Electronic component **220** can comprise terminals **221** and internal interconnects **222**. Substrate **210**, encapsulant **230**, and interconnects **240** can comprise or be referred to as a semiconductor package **202** and can provide protection for electronic component **220** from external elements or environmental exposure. In addition, semiconductor package **202** can provide electrical couplings between an external component and electronic component **220**.

FIGS. 6A and 6B show cross-sectional views of an example method for manufacturing an example semiconductor device. FIG. 6A shows a cross-sectional view of semiconductor device **300** at an early stage of manufacture.

In the example shown in FIG. 6A, semiconductor device **100** can be prepared. Example method for manufacturing first semiconductor device **100** shown in FIG. 6A can be similar to the example method for manufacturing semiconductor device **100** shown in FIGS. 2A to 2G, FIGS. 3A to 3C, and FIGS. 4A and 4B.

In the example shown in FIG. 6A and FIG. 6B, interconnects **240** of second semiconductor device **200** can be electrically connected to top surfaces **112a** of substrate lands

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**112** of first semiconductor device **100**. Second semiconductor device **200** can be stacked on first semiconductor device **100**.

In some examples, pick-and-place equipment (not shown) can pick up second semiconductor device **200** to place second semiconductor device **200** on top surfaces **112a** of substrate lands **112** of first semiconductor device **100**. Subsequently, second semiconductor device **200** can be electrically connected to first semiconductor device **100** by mass reflow, thermal compression, or laser assist bonding.

In substrate **210** of second semiconductor device **200**, conductive structures **211**, **213**, and **215** having a multitude of conductors, traces, or patterns can be provided within dielectric layers **212** and **214**. Substrate **210** is shown comprising three conductive structures **211**, **213** and **215** and two dielectric layers **212** and **214**, but the number of conductive layers and dielectric layers of substrate **210** can be fewer or more. Substrate **210** can be similar to redistribution structure **120** or substrate **110** and can be similarly formed. Substrate **210** can comprise or be referred to as a redistribution structure, an interposer, or a printed circuit board.

In some examples, the non-active region of electronic component **220** can be adhered to a top surface of substrate **210** using an adhesive, and terminals **221** in an active region of electronic component **220** can be electrically connected to conductive layer **215** of substrate **210** through internal interconnectors **222** in the form of, for example, wires. In some examples, the active region of electronic component **220** can be located at its bottom surface and can be electrically connected to conductive structure **215** of substrate **210** in a flip-chip configuration through internal interconnectors **222** in the form of, for example, conductive bumps or conductive posts. Electronic component **220** can be similar to electronic component **120** and can be similarly formed as electronic component **120**. Electronic component **220** can be electrically connected to interconnects **240** through internal interconnectors **222** and substrate **210**.

Encapsulant **230** can be formed to cover both top surface **210a** of substrate **210** and electronic component **220**. Encapsulant **230** can be similar to encapsulant **130** and can be similarly formed as encapsulant **130**.

Interconnects **240** can be electrically connected to conductive structure **211** of substrate **210**. Conductive structures **211** can be similar to second conductive structure **144** and can be similarly formed as second conductive structure **144**. Interconnects **240** can be similar to interconnects **150** and can be similarly formed as interconnects **150**. Interconnects **240** can electrically connect substrate **210** and substrate **110** to each other. Interconnects **240** can be electrically connected to electronic component **220** through substrate **210**. Interconnects **240** can be electrically connected to electronic component **120** through substrate **110** and redistribution structure **140**. Interconnects **240** can electrically connect first semiconductor device **100** and second semiconductor device **200** to each other. Electronic component **220** can be electrically connected to interconnects **150** through substrate **210**, interconnects **240**, substrate **110**, substrate interconnects **117** and redistribution structure **140**.

FIG. 7 shows a cross-sectional view of an example electronic device **10'**. In the example shown in FIG. 7, electronic device **10'** can comprise backside substrate **11'**, internal interconnects **110'**, electronic component **12'**, electronic component **13'** (optional), interface layer **14'**, frontside substrate **15'**, encapsulant **18'**, and external terminals **19'**.

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Backside substrate 11' can comprise conductive structure 111', dielectric structure 112' and cavity 115'. Conductive structure 11' can comprise inward terminals 1111', outward terminals 1112' and cavity terminals 1113'. Cavity 115' can comprise cavity base 1151' and cavity wall 1152'. Electronic component 12' can comprise component terminals 121'. Electronic component 13' can comprise component terminals 131'. Frontside substrate 15' can comprise conductive structure 151' and dielectric structure 152'. Conductive structure 151' can comprise inward terminals 1511' and outward terminals 1512'. In some examples, features, elements, components, or manufacturing stages of electronic device 10' can be similar to corresponding ones of electronic device 100 described with respect to FIGS. 1-6. Backside substrate 11' can comprise base substrate 1101' and cavity substrate 1102' adjacent to base substrate 1101'. In some examples, backside substrate 11' is over a top side of frontside substrate 15'. In some examples, conductive structure 151' of frontside substrate 15' can be coupled with internal interconnect 110' of backside substrate 11'.

Backside substrate 11', internal interconnects 110', interface layer 14', frontside substrate 15', encapsulant 18', and external terminals 19' can be referred to as a semiconductor package and package can provide protection for electronic components 12' and 13' from external elements or environmental exposure. The semiconductor package can provide electrical coupling between electronic components 112', 113' or outward terminals 1112' with other electrical components external to the semiconductor package. Backside substrate 11' can comprise cavity 115' and internal interconnect 110' contacting frontside substrate 15'. Electronic component 12' can be over the top side of frontside substrate 15' and can be in cavity 115'. Electronic component 12' can be coupled with conductive structure 151' of frontside substrate 15'. Encapsulant 18' can be in cavity 115' and over the top side of frontside substrate 15'. In some examples, encapsulant 18' can contact a lateral side of electronic component 12', a lateral side of cavity 115', or a lateral side of internal interconnect 110'. In some examples, one or more lateral sides of backside substrate 11' can be free of any encapsulant 18'.

FIGS. 8A to 8H show cross-sectional views of an example method for manufacturing electronic device 10'. FIG. 8A shows a cross-sectional view of electronic device 10' at an early stage of manufacture.

In the example shown in FIG. 8A, backside substrate 11' and electronic components 12' and 13' can be provided. In some examples, backside substrate 11' can comprise or be referred to as a cavity substrate or a laminate substrate. In some examples, backside substrate 11' be defined by base substrate 1101' and cavity substrate 1102' coupled to base substrate 1101' and having cavity 115'.

Backside substrate 11' can be similar to substrate 110 of semiconductor device 100 as shown in FIGS. 1-6. For example, cavity substrate 1102' and cavity 115' can be similar to respective portions of substrate 110 and cavity 119 of semiconductor device 100. Electronic component 12' or 13' can be similar to electronic component 120 of semiconductor device 100.

In some examples, backside substrate 11' can be a monolithic or single substrate or structure, where base substrate 1101' and cavity substrate 1102' define respective portions of backside substrate 11', and are formed integral with each other. In some examples, backside substrate 11' can be a combined substrate, where backside substrate 11' and cavity

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substrate 1102' define respective portions of backside substrate 11', but are formed separately and then attached together.

In some examples, cavity substrate 1102' can comprise a single substrate extending around an entire perimeter of electronic component 12', such as a square ring around cavity 115'. In some examples, cavity substrate 1102' can comprise multiple substrates or distinct substrate portions separated from each other, such as a first substrate portion along a first lateral side of electronic component 12' and a second substrate portion along a second lateral side of electronic component 12', without extending around the entire perimeter of electronic device 10'.

Cavity 115' can comprise or be defined by cavity base 1151', which is a partial region of the inward side of base substrate 1101', and cavity wall 1152', which is a part of an inner sidewall of cavity substrate 1102'. In some examples, the thickness of base substrate 1101' can range from approximately 50  $\mu\text{m}$  to approximately 1000  $\mu\text{m}$ . In some examples, the thickness of cavity substrate 1102' can range from approximately 100  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ . In some examples, the width of cavity 115' can range from approximately 100  $\mu\text{m}$  to approximately 1000  $\mu\text{m}$ .

Backside substrate 11' can comprise conductive structure 111' and dielectric structure 112'. Conductive structure 111' can comprise portions of conductive layers defining conductive paths or elements such as traces, pads or vias. Conductive structure 111' can be provided in a variety of manners, such as plating, sputtering, or deposition. Conductive structure 111' can comprise copper, aluminum, nickel, palladium, gold, silver, titanium, or tungsten. In some examples, the thickness of individual layers of conductive structure 111' can range from approximately 3  $\mu\text{m}$  to approximately 50  $\mu\text{m}$ . The conductive paths of conductive structure 111' can transmit electrical signals in vertical directions or horizontal directions.

Conductive structure 111' can comprise inward terminals 1111' arranged on the inward side of cavity substrate 1102'. In some examples, the thickness of inward terminals 1111' can range from approximately 3  $\mu\text{m}$  to approximately 50  $\mu\text{m}$ . In some examples, conductive structure 111' can comprise outward terminals 1112' arranged on outward side of base substrate 1101'. In some examples, the thickness of outward terminals 1112' can range from approximately 3  $\mu\text{m}$  to approximately 50  $\mu\text{m}$ . In some examples other electronic components or packages can be coupled on outward terminals 1112' of backside substrate 11'.

Conductive structure 111' can comprise cavity terminals 1113' arranged the inward side of cavity base 1151'. In some examples, the thickness of cavity terminals 1113' can range from approximately 3  $\mu\text{m}$  to approximately 50  $\mu\text{m}$ . In some examples, inward terminals 1111', outward terminals 1512', or cavity terminals 1113' can comprise or be referred to as pads, bumps, or under-bump metallizations (UBMs).

Dielectric structure 112' can comprise one or more dielectric layers interposed between one or more levels of conductive structure 111' or between adjacent elements of conductive structure 111'. Dielectric structure 112' can comprise or be referred to as an insulating resin, a pre-preg resin, a polymer, a core layer, a ceramic, etc. In some examples, the thickness of individual layers of dielectric structure 112' can range from approximately 15  $\mu\text{m}$  to approximately 100  $\mu\text{m}$ . Dielectric structure 112' can provide backside substrate 11' with structural integrity for supporting and routing conductive structure 111'.

In some examples, backside substrate 11' can be provided in a matrix type where multiple cavity substrates 1102' have

rows and columns on one base substrate **1101'** in order to improve the production efficiency of multiple of electronic devices. In some examples, base substrate **1101'** can be in the form of one wide rectangular panel or in the form of a disk, and cavity substrate **1102'** can be provided in the form of one or more rectangles divided into multiple pieces on base substrate **1101'**.

In some examples, backside substrate **11'** can be a pre-formed substrate. The pre-formed substrate can be manufactured prior to attachment to an electronic device and can comprise dielectric layers between respective conductive layers. The conductive layers can comprise copper and can be formed using an electroplating process. The dielectric layers can be relatively thicker non-photo-definable layers that can be attached as a pre-formed film rather than as a liquid and can include a resin with fillers such as strands, weaves, or other inorganic particles for rigidity or structural support. Since the dielectric layers are non-photo-definable, features such as vias or openings can be formed by using a drill or laser. In some examples, the dielectric layers can comprise a prepreg material or Ajinomoto Buildup Film (ABF). The pre-formed substrate can include a permanent core structure or carrier such as, for example, a dielectric material comprising bismaleimide triazine (BT) or FR4, and dielectric and conductive layers can be formed on the permanent core structure. In other examples, the pre-formed substrate can be a coreless substrate omitting the permanent core structure, and the dielectric and conductive layers can be formed on a sacrificial carrier that is removed after formation of the dielectric and conductive layers and before attachment to the electronic device. The pre-formed substrate can be referred to as a printed circuit board (PCB) or a laminate substrate. Such pre-formed substrate can be formed through a semi-additive or modified-semi-additive process.

Electronic component **12'** can be attached to cavity base **1151'** of backside substrate **11'**. In some examples, an inactive side of electronic component **12'** can be attached onto cavity base **1151'** via interface layer **14'**. Interface layer **14'** can be between electronic component **12'** and backside substrate **11'**. In some examples, interface layer **14'** can comprise or be referred to as a die attach film, a thermal interface material, or an adhesive. In some examples, interface layer **14'** can be a dielectric or electrically non-conductive. In some examples, interface layer **14'** can comprise a metallic material or can be electrically conductive. In some examples, interface layer **14'** can be thermally conductive.

When interface layer **14'** is a die attach film, a bond line thickness (BLT) can be uniformly maintained and a narrow keep out zone (KOZ) can be provided to reduce or avoid contamination surrounding electronic component **12'**. In some examples, if interface layer **14'** is provided in a liquid phase a wider keep-out zone can be provided. In some examples, contamination of cavity terminal **1113'** can be prevented by die attach film **14'**. In some examples, interface layer **14'** can first be attached to the inactive side of electronic component **12'**, and electronic component **12'** can then be attached to cavity base **1151'**. In some examples, interface layer **14'** can first be pre-attached to cavity base **1151'**, and electronic component **12'** can then be attached to cavity base **1151'**.

Electronic component **12'** can comprise or be referred to as a semiconductor die, a semiconductor package, an active component, a passive component. In some examples, electronic component **12'** can also comprise digital signal processors (DSPs), network processors, power management units, audio processors, radio-frequency (RF) circuits, wireless baseband system-on-a-chip (SoC) processors, sensors,

or application specific integrated circuits. In some examples, the thickness of electronic component **12'** can be approximately 50  $\mu\text{m}$  to approximately 780  $\mu\text{m}$ . In some examples, electronic component **12'** can perform various calculation and control processing operations, store data, or remove noise from an electrical signal.

One or more electronic components **13'** can be in cavity **115'** and adjacent to electronic component **12'**, and can be attached to cavity base **1151'** of backside substrate **11'**. In some examples, component terminals **131'** of electronic component **13'** can be coupled to cavity terminals **1113'** of backside substrate **11'**. Electronic component **13'** can comprise or be referred to as a semiconductor die, a semiconductor package, or a passive component such as a capacitor or inductor. In some examples, the thickness of electronic component **13'** can be different than the thickness of electronic component **12'**. As shown in FIG. 8A, such thickness can be smaller than that of electronic component **12'**, but there can be examples where the thickness can be larger. In some examples, the thickness of electronic component **13'** can range from approximately 50  $\mu\text{m}$  to approximately 1000  $\mu\text{m}$ . In some examples, electronic component **13'** can filter noise of electronic device **10'** or temporarily store an electrical signal.

In some examples, internal interconnects **110'** can be electrically coupled to inward terminals **1111'** of backside substrate **11'**. In some examples, internal interconnects **110'** can be provided before electronic component **12'** or **13'** is coupled to backside substrate **11'** or after electronic component **12'** or **13'** is coupled to backside substrate **11'**. Internal interconnects **110'** can comprise or be referred to as pillars, posts, bumps, or metal-core solder-coated balls. Internal interconnects **110'** can be provided on backside substrate **11'** in a variety of manners, such as plating, sputtering, soldering, or deposition. For example, internal interconnects **110'** can be formed on inward terminals **1111'** via a plating, sputtering, soldering, or deposition process. Internal interconnect **110'** can comprise copper, aluminum, nickel, palladium, gold, silver, tungsten or titanium. The width of internal interconnects **110'** can be smaller compared to the width of a solder ball. Accordingly, the pitch of internal interconnects **110'** can be relatively small. In some examples, the thickness or width of internal interconnect **110'** can range from approximately 100  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ . Internal interconnects **110'** can serve to couple backside substrate **11'** to frontside substrate **15'**. The general copper core ball or copper core cube can be omitted by internal interconnect **110'**, or an adhesive dispensing process can be omitted to simplify the manufacturing process of electronic device **10'**.

Component terminals **121'** can protrude from electronic component **12'**. In some examples, component terminals **121'** can be provided before electronic component **12'** is coupled to backside substrate **11'**. Component terminals **121'** can comprise or be referred to as pillars, posts, or bumps. Component terminals **121'** can be provided on electronic component **12'** in various manners, such as plating, sputtering, or vapor deposition. Component terminals **121'** can comprise copper, aluminum, nickel, palladium, gold, silver, tungsten, or titanium. In some examples, the time of providing component terminals **121'** can be similar or concurrent with the time of providing internal interconnects **110'**. In some examples, the thickness or width of the component terminals **121'** can be smaller than the thickness or width of the internal interconnects **110'**. In some examples, the pitch of component terminals **121'** can be smaller than the pitch of internal interconnects **110'**. In some examples, the top side of

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component terminals 121' can be substantially coplanar with the top side of internal interconnects 110'. In some examples, the thickness or width of component terminals 121' can range from approximately 20  $\mu\text{m}$  to approximately 500  $\mu\text{m}$ . Component terminal 121' can couple electronic component 12' to frontside substrate 15'.

FIG. 8B shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 8B, a singulation process can be performed. In some examples, by sawing an array of backside substrates 11' with a mechanical wheel or a laser beam, singulated backside substrates 11' can be provided. In some examples, lateral sides of base substrate 1101' and lateral sides of cavity substrate 1102' can be coplanar with each other by the singulation process. In some examples, after the singulation process, the lateral sides of base substrate 1101' and the lateral sides of cavity substrate 1102' can form different planes. In some examples, after the singulation process, the lateral sides of cavity substrate 1102' can be positioned inward of the lateral sides of base substrate 1101'.

FIG. 8C shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 8C, carrier 16' can be provided. In some examples, carrier 16' can comprise or be referred to as a wafer, a panel, a strip, a plate or a board. In some examples, carrier 16' can be ceramic, glass, or metal. In some examples, backside substrate 11' can be attached onto carrier 16' via temporary adhesive layer 17'. In some examples, backside substrates 11' can be provided or arranged in a matrix type where multiple cavity substrates 1102' define rows and columns. In some examples, temporary adhesive layer 17' can be provided on carrier 16' in various manners, such as coating, printing, inkjet printing, or an adhesive film or adhesive tape. In some examples, temporary adhesive layer 17' can be a thermally releasable tape or film, or a photo-releasable tape or film, and the adhesiveness can be weakened or removed by heat or light. In some examples, the adhesiveness of temporary adhesive layer 17' can be weakened or removed by physical or chemical external force. In this way, carrier 16' can allow multiple components to be integrally handled during subsequent processes.

FIG. 8D shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 8D, an encapsulation process can be performed. In some examples, encapsulant 18' can cover backside substrate 11', electronic components 12' and 13', component terminals 121' and 131', and internal interconnects 110'. In some examples, encapsulant 18' can fill cavity 115' while covering cavity base 1151' and cavity wall 1152'. In some examples, encapsulant 18' can cover cavity substrate 1102'. In some examples, encapsulant 18' can comprise or be referred to as a molding compound, an epoxy resin, a polymer with inorganic filler, or a sealant. In some examples, encapsulant 18' can comprise or be referred to as an epoxy molding compound, an epoxy molding resin, or a sealant. In some examples, encapsulant 18' can comprise an organic resin, an inorganic filler, a curing agent, a catalyst, a coupling agent, a colorant, or a flame retardant. In some examples, encapsulant 18' can be provided in a variety of manners, such as film assist molding, compression molding, transfer molding, liquid encapsulant molding, vacuum lamination, or paste printing. In some examples, the thickness of encapsulant 18' can be approximately 100  $\mu\text{m}$  to 1000  $\mu\text{m}$ . Such encapsulant 18' can protect electronic components 12' and 13', component terminals 121' and 131' and internal interconnects 110' from exposure to external elements or environments.

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FIG. 8E shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 2E, carrier 16' can be removed. In some examples, heat, light, a chemical solution, or a physical external force can be provided to remove or reduce the adhesiveness of temporary adhesive layer 17', thereby allowing carrier 16' to be removed from backside substrate 11'. Accordingly, the side of backside substrate 11', for example, outward terminals 1112', can be exposed.

FIG. 8F shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 8F, a grinding process can be provided. In some examples, some top portions of encapsulant 18' can be removed by mechanical grinding or chemical etching. Accordingly, internal interconnects 110' and component terminals 121' can be exposed. In some examples, the top side of the internal interconnects 110' or the top side of component terminals 121' can be coplanar with the top side of encapsulant 18'. The grinding process can also remove top portions internal interconnects 110' or of component terminals 121' to reveal or define their respective top sides substantially coplanar with the top side of encapsulant 18'. In some examples, grinding of encapsulant 18' and a portion of internal interconnect 110' can occur before providing frontside substrate 15' as shown in and described with FIG. 8G.

FIG. 8G shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 8G, frontside substrate 15' can be provided. Frontside substrate 15' can be provided on encapsulant 18' and coupled to internal interconnects 110' or component terminals 121'.

In some implementations, frontside substrate 15' can be formed straight on the structure of FIG. 8F. For example, frontside substrate can comprise or be referred to as a redistribution layer substrate or RDL substrate, or a coreless substrate. In some examples, there can be implementations where frontside substrate 15' can be a pre-formed substrate and then coupled with the structure of FIG. 8F. In some examples, the thickness of frontside substrate 15' can be thinner than that of base substrate 1101' or of cavity substrate 1102', such as where frontside substrate 15' is an RDL substrate. In some examples, the thickness of frontside substrate 15' can range from approximately 10  $\mu\text{m}$  to approximately 50  $\mu\text{m}$ . In some examples, frontside substrate 15' can be an RDL substrate and backside substrate 11' can be a pre-formed substrate.

Frontside substrate 15' can comprise conductive structure 151' and dielectric structure 152'. Conductive structure 151' can comprise conductive layers defining conductive paths having elements such as traces, pads or vias. The conductive paths of conductive structure 151' can transmit electrical signals in vertical directions or horizontal directions.

Conductive structure 151' can comprise inward terminals 1511' and outward terminals 1512'. Inward terminals 1511' can comprise or be referred to as pads or vias. Inward terminals 1511' can be coupled to internal interconnects 110' or component terminals 121'. In some examples, outward terminals 1512' can comprise or be referred to as pads, traces, or under bumped metals (UBMs).

Dielectric structure 152' can comprise one or more dielectric layers interposed between one or more levels of conductive structure 151' or between adjacent elements of conductive structure 151'. In some examples, the side, or upper side, of outward terminals 1512' can be lower than the side, or upper side, of the dielectric structure 152'.

In some examples, front side substrate 15' can be a redistribution layer ("RDL") substrate. RDL substrates can comprise one or more conductive redistribution layers and

one or more dielectric layers that (a) can be formed layer by layer over an electronic device to which the RDL substrate is to be electrically coupled, or (b) can be formed layer by layer over a carrier that can be entirely removed or at least partially removed after the electronic device and the RDL substrate are coupled together. RDL substrates can be manufactured layer by layer as a wafer-level substrate on a round wafer in a wafer-level process, or as a panel-level substrate on a rectangular or square panel carrier in a panel-level process. RDL substrates can be formed in an additive buildup process that can include one or more dielectric layers alternatingly stacked with one or more conductive layers that define respective conductive redistribution patterns or traces configured to collectively (a) fan-out electrical traces outside the footprint of the electronic device, or (b) fan-in electrical traces within the footprint of the electronic device. The conductive patterns can be formed using a plating process such as, for example, an electroplating process or an electroless plating process. The conductive patterns can comprise an electrically conductive material such as, for example, copper or other plateable metal. The locations of the conductive patterns can be made using a photo-patterning process such as, for example, a photolithography process and a photoresist material to form a photolithographic mask. The dielectric layers of the RDL substrate can be patterned with a photo-patterning process, which can include a photolithographic mask through which light is exposed to photo-pattern desired features such as vias in the dielectric layers. The dielectric layers can be made from photo-definable organic dielectric materials such as, for example, polyimide (PI), benzocyclobutene (BCB), or polybenzoxazole (PBO). Such dielectric materials can be spun-on or otherwise coated in liquid form, rather than attached as a pre-formed film. To permit proper formation of desired photo-defined features, such photo-definable dielectric materials can omit structural reinforcements or can be filler-free, without strands, weaves, or other particles, that could interfere with the light from the photo-patterning process. In some examples, such filler-free characteristics of filler-free dielectric materials can permit a reduction of the thickness of the resulting dielectric layer. Although the photo-definable dielectric materials described above can be organic materials, in other examples the dielectric materials of the RDL substrates can comprise one or more inorganic dielectric layers. Some examples of inorganic dielectric layer(s) can comprise silicon nitride ( $\text{Si}_3\text{N}_4$ ), silicon oxide ( $\text{SiO}_2$ ), or silicon oxynitride ( $\text{SiON}$ ). The inorganic dielectric layer or layers can be formed by growing the inorganic dielectric layers using an oxidation or nitridization process instead using photo-defined organic dielectric materials. Such inorganic dielectric layers can be filler-free, without strands, weaves, or other dissimilar inorganic particles. In some examples, the RDL substrates can omit a permanent core structure or carrier such as, for example, a dielectric material comprising bismaleimide triazine (BT) or FR4, and these types of RDL substrates can be referred to as a coreless substrate.

FIG. 8H shows a cross-sectional view of electronic device 10' at a later stage of manufacture. In the example shown in FIG. 2H, external terminals 19' can be provided. In some examples, external terminals 19' can be provided on outward terminals 1512' of frontside substrate 15'. External terminal 19' can comprise or be referred to as solder balls or bumps. In some examples, external terminals 19' can be coupled to outward terminals 1512' via a low melting point material. In some examples, external terminals 19' can be comprised materials such as Sn, Ag, Pb, Cu, Sn—Pb, Sn37-Pb, Sn95-

Pb, Sn—Pb—Ag, Sn—Cu, Sn—Ag, Sn—Au, Sn—Bi, or Sn—Ag—Cu. The thickness, or diameter, of external terminal 19 can be approximately 100  $\mu\text{m}$  to 600  $\mu\text{m}$ . External terminals 19' can couple electronic device 10' to an external device.

Thereafter, a singulation process can be carried out along the dotted lines to define individual electronic devices 10'. In some examples, when multiple backside substrates 11' are provided at regular intervals, encapsulant 18' can exist between multiple backside substrates 11'. In some examples, encapsulant 18' existing between multiple backside substrates 11' can be singulated by a mechanical wheel, a laser beam, etc. Encapsulant 18' and frontside substrate 15' can be singulated together. By the sawing process, the lateral sides of backside substrate 11', lateral sides of encapsulant 18', and lateral sides of frontside substrate 15' can be all coplanar with one another or can form similar planes.

FIG. 9 shows a cross-sectional view of an example electronic device 10". Electronic device 10" can be similar or same as electronic device 10' shown in FIG. 7, and can comprise encapsulant 18". Encapsulant 18" can be similar or same as encapsulant 18', and can cover the lateral sides of backside substrate 11'. Electronic device 10" shown in FIG. 9 can be a cross-sectional view of the same electronic device 10' shown in FIG. 7, but cut across a different line perpendicular to the cross-section line of FIG. 7.

In some examples, the lateral sides of encapsulant 18" can be coplanar with the lateral sides of frontside substrate 15'. In some examples, the width of frontside substrate 15' can be larger than the width of backside substrate 11'. In some examples, the width of encapsulant 18" covering the lateral sides of backside substrate 11' can be approximately 10  $\mu\text{m}$  to 50  $\mu\text{m}$ . Encapsulant 18" covering the lateral sides of backside substrate 11' can improve insulation or protection of backside substrate 11'.

In some examples, by reducing the singulation width of the mechanical wheel or laser beam during the singulation process of encapsulant 18", narrower regions of encapsulant 18" can be removed, and thus some regions of encapsulant 18" can remain covering or contacting one or more external lateral sides of backside substrate 11'. In some examples, during the process of arranging multiple backside substrates 11' in a matrix, the interval between multiple backside substrates 11' can be made relatively wider, for example by making the width of some regions of encapsulant 18" relatively large, thereby allowing some regions of encapsulant 18" to remain on the lateral sides of backside substrate 11' after the singulation process of encapsulant 18". In some examples, the width of frontside substrate 15' is greater than the width of backside substrate 11' to accommodate the regions of encapsulant 18" covering or contacting the one or more external lateral sides of backside substrate 11'.

In some examples, electronic device 10' of FIG. 7 or electronic device 10" of FIG. 9 can be used in the place of package 100 of FIG. 5 to provide a semiconductor structure. In such examples, electronic device 10' or electronic device 10" can comprise a first semiconductor device comprising a frontside substrate 15' comprising a conductive structure 151', a backside substrate 11' comprising a base substrate 1101' and a cavity substrate 1102' adjacent to the base substrate 1101'. The backside substrate 1101' can be over a top side of the frontside substrate 15', and can comprise a cavity 115' and an internal interconnect 110' contacting the frontside substrate 15'. Electronic component 12' can be over the top side of the frontside substrate 15' and in the cavity 115'. Electronic component 12' can be coupled with the conductive structure 151' via a component terminal 121'.



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Encapsulant **18'** can be in the cavity **115'** and on the top side of the frontside substrate **15'** bounding a lateral side of electronic component **12'** and internal interconnect **110'**. Package **200** of FIG. 5 can comprise a semiconductor device over a top side of electronic device **10'** or electronic device **10"**. Package **200** can be coupled with a substrate land **112** on a top side of the backside substrate **11'**.

The present disclosure includes reference to certain examples. It will be understood, however, by those skilled in the art that various changes may be made, and equivalents may be substituted without departing from the scope of the disclosure. In addition, modifications may be made to the disclosed examples without departing from the scope of the present disclosure. Therefore, it is intended that the present disclosure is not limited to the examples disclosed, but that the disclosure will include all examples falling within the scope of the appended claims.

The invention claimed is:

1. A semiconductor structure, comprising:
  - a frontside substrate comprising a conductive structure;
  - a backside substrate comprising a base substrate and a cavity substrate adjacent to the base substrate, wherein the backside substrate is over a top side of the frontside substrate and has a cavity and an internal interconnect contacting the frontside substrate;
  - a first electronic component over the top side of the frontside substrate and in the cavity, wherein the first electronic component is coupled with the conductive structure;
  - an encapsulant in the cavity and on the top side of the frontside substrate, contacting a lateral side of the first electronic component, a lateral side of the cavity, and a lateral side of the internal interconnect; and
  - an interface layer between a top side of the first electronic component and the backside substrate, wherein the interface layer is discrete from the encapsulant.
2. The semiconductor structure of claim 1, wherein the backside substrate comprises a monolithic structure comprising the base substrate and the cavity substrate.
3. The semiconductor structure of claim 1, comprising a second electronic component in the cavity and adjacent to the first electronic component.
4. The semiconductor structure of claim 1, wherein a lateral side of the backside substrate is free of the encapsulant.
5. The semiconductor structure of claim 1, wherein the encapsulant contacts an external lateral side of the backside substrate.
6. The semiconductor structure of claim 1, wherein the conductive structure of the frontside substrate is coupled with the internal interconnect of the backside substrate.
7. The semiconductor structure of claim 1, wherein the interface layer comprises an electrically conductive material.
8. The semiconductor structure of claim 1, wherein the frontside substrate comprises a redistribution layer (RDL) substrate.
9. The semiconductor structure of claim 1, wherein the frontside substrate comprises a redistribution layer substrate, and the backside substrate comprises a pre-formed substrate.
10. The semiconductor structure of claim 1, wherein a width of the frontside substrate is greater than a width of the backside substrate.
11. A method to manufacture a semiconductor structure, comprising:

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- providing a backside substrate having a cavity and an internal interconnect, wherein the backside substrate comprises a base substrate and a cavity substrate contacting the base substrate;
- placing an electronic component having a component terminal in the cavity of the backside substrate, wherein an interface material is between the electronic component and the backside substrate;
- providing an encapsulant in the cavity on a top side of the backside substrate and contacting a lateral side of the electronic component, the internal interconnect, and the component terminal, wherein the encapsulant is discrete from the interface material; and
- providing a frontside substrate over the top side of the backside substrate, wherein the frontside substrate has a conductive structure coupled with the internal interconnect.

12. The method of claim 11, comprising grinding the encapsulant and a portion of the internal interconnect before providing the frontside substrate.

13. The method of claim 11, wherein the conductive structure comprises an inward terminal, and the internal interconnect is formed on the inward terminal via a plating process.

14. The method of claim 11, wherein providing the frontside substrate comprises:

- forming a dielectric layer of the frontside substrate over the encapsulant, the backside substrate, and the electronic component; and
- forming a conductive layer of the frontside substrate over the dielectric layer and coupled to the backside substrate and the electronic component through the dielectric layer.

15. A semiconductor structure, comprising:

- a first semiconductor device comprising:
  - a frontside substrate comprising a conductive structure;
  - a backside substrate comprising a base substrate and a cavity substrate adjacent to the base substrate, wherein the backside substrate is over a top side of the frontside substrate and has a cavity and an internal interconnect contacting the frontside substrate;
  - a first electronic component over the top side of the frontside substrate and in the cavity, wherein the first electronic component is coupled with the conductive structure via a component terminal;
  - an encapsulant in the cavity and on the top side of the frontside substrate bounding a lateral side of the first electronic component and the internal interconnect;
  - an interface layer between a top side of the first electronic component and the backside substrate, wherein the interface layer is discrete from the encapsulant; and
- a second semiconductor device over a top side of the first semiconductor device, wherein the second semiconductor device is coupled with a substrate land on a top side of the backside substrate.

16. The semiconductor structure of claim 15, wherein the backside substrate comprises a monolithic structure comprising the base substrate and the cavity substrate.

17. The semiconductor structure of claim 15, comprising a second electronic component in the cavity and adjacent to the first electronic component.

18. The semiconductor structure of claim 15, wherein a lateral side of the backside substrate is free of the encapsulant.

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**19.** The semiconductor structure of claim **15**, wherein the encapsulant contacts an external lateral side of the backside substrate.

**20.** The semiconductor structure of claim **15**, wherein the interface layer comprises an electrically conductive material.

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