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Kuo et al.

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(54) **CIRCUIT BOARD STRUCTURE AND MANUFACTURING METHOD THEREOF**

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H05K 1/16 (2006.01)
H05K 3/00 (2006.01)

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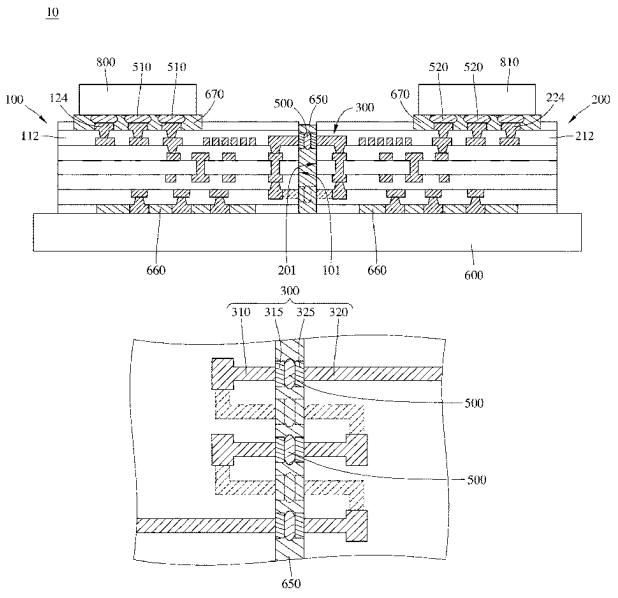
(57) **ABSTRACT**

A circuit board structure including a first circuit board, a second circuit board, a conductive coil and a first molding compound and a manufacturing method thereof. The first circuit board has a first side surface. The second circuit board has a second side surface facing the first side surface and being spaced apart from the first side surface. The conductive coil is in a spiral shape and includes a first coil pattern and a second coil pattern. The first coil pattern is disposed in the first circuit board. The second coil pattern is disposed in the second circuit board. The first coil pattern is electrically connected to the second coil pattern. The first molding compound is magnetic and filled in a gap located between the first side surface and the second side surface. The conductive coil surrounds at least a part of the first molding compound.

17 Claims, 14 Drawing Sheets



(58) **Field of Classification Search**
CPC ... H05K 2201/0919; H05K 2201/1034; H05K 1/145; H01F 2027/2814
See application file for complete search history.

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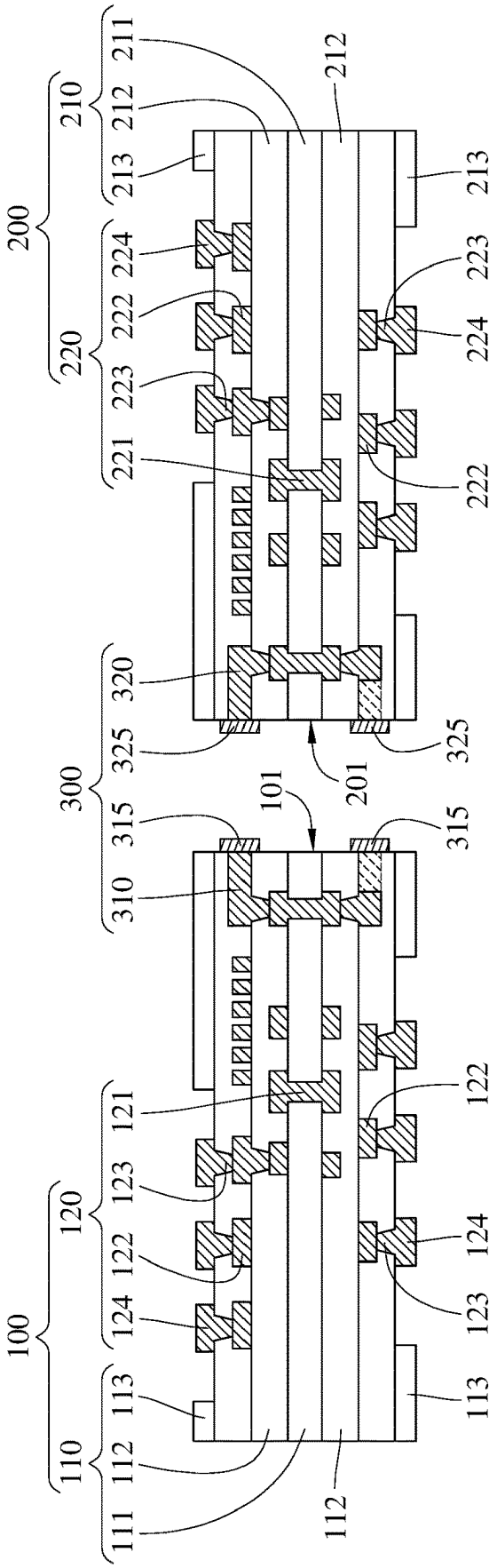
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210
211
212
213
220
221
222
223
224
300
310
315
320
325
101
201
100
110
111
112
113
120
121
122
123
124

FIG. 1

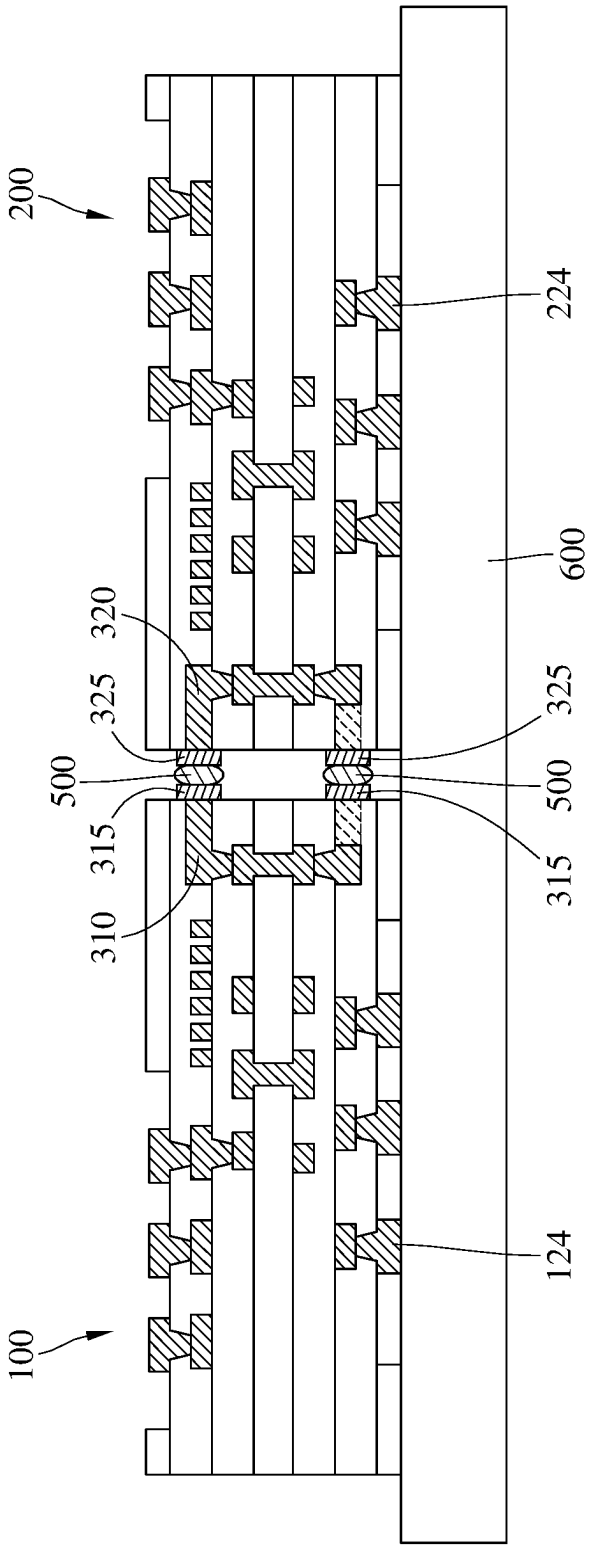


FIG. 2

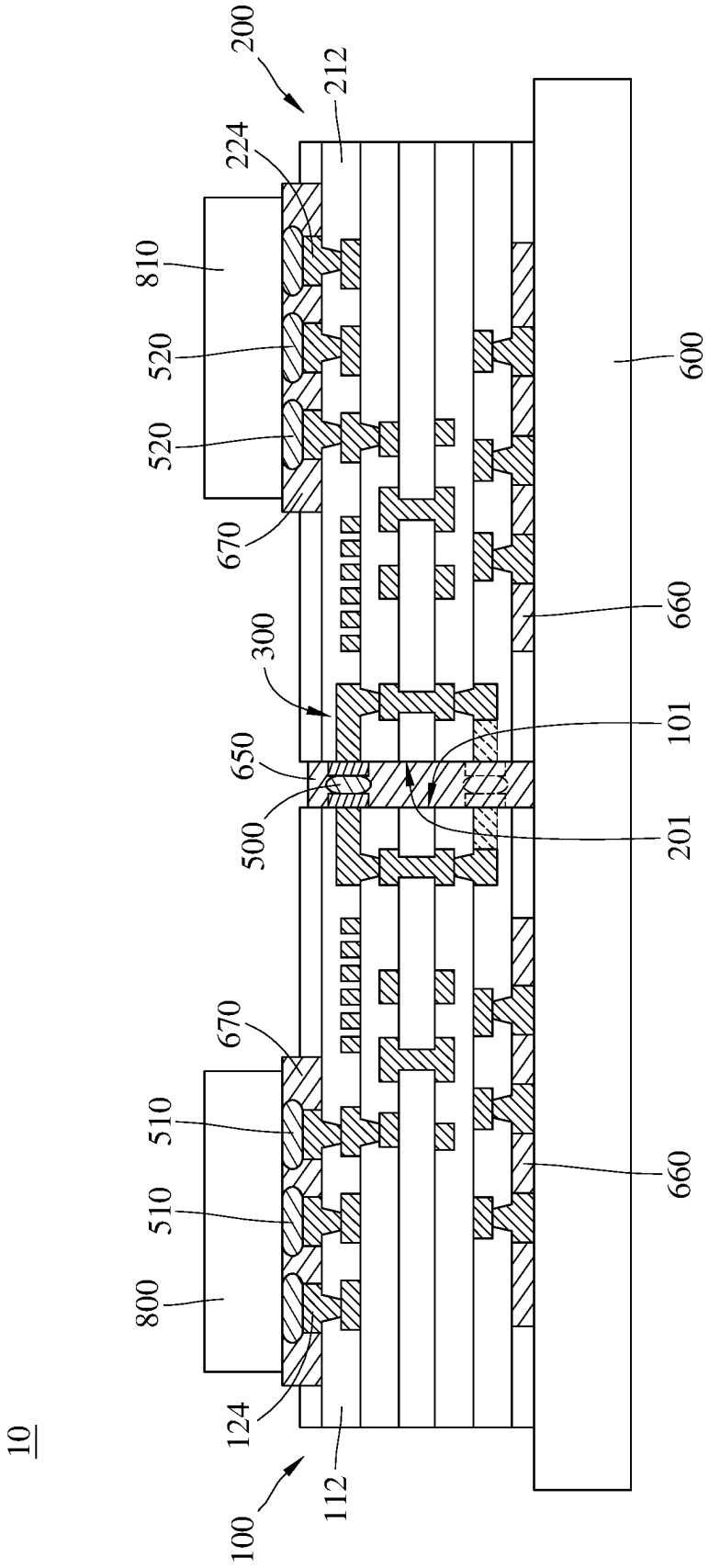

10
100
112
124
800
510
510
670
500
650
300
660
600
520
520
810
224
212
200
101
201
660
670

FIG. 3

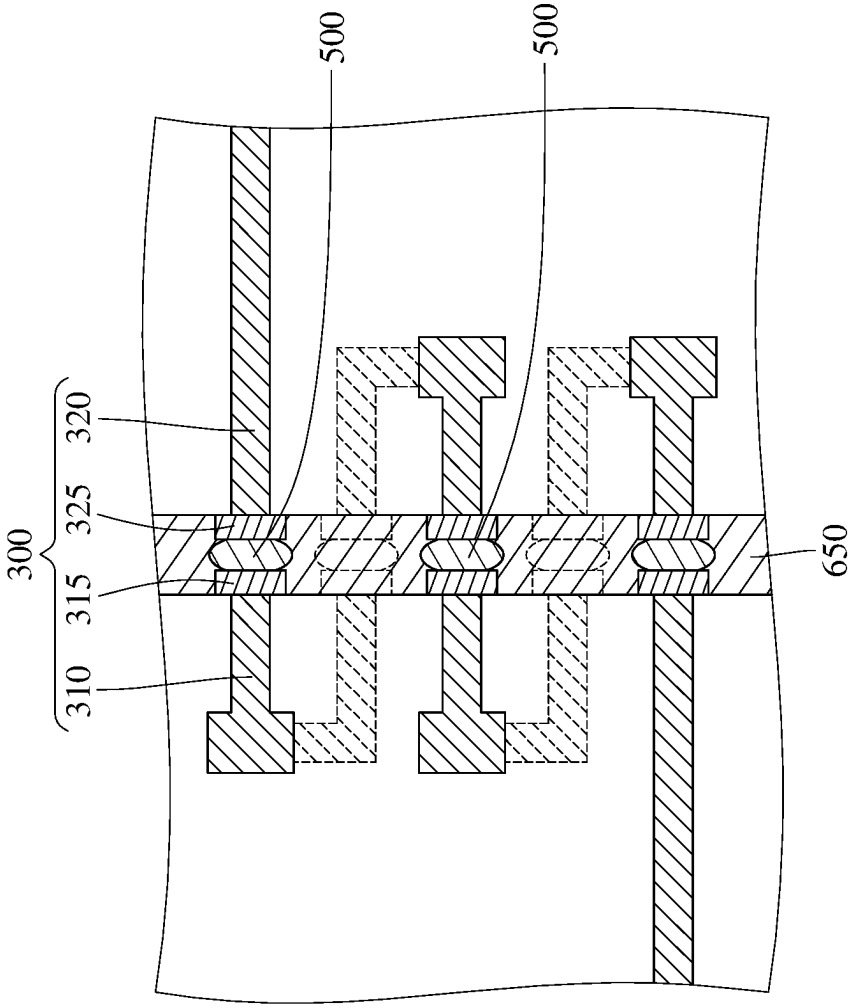


FIG. 4

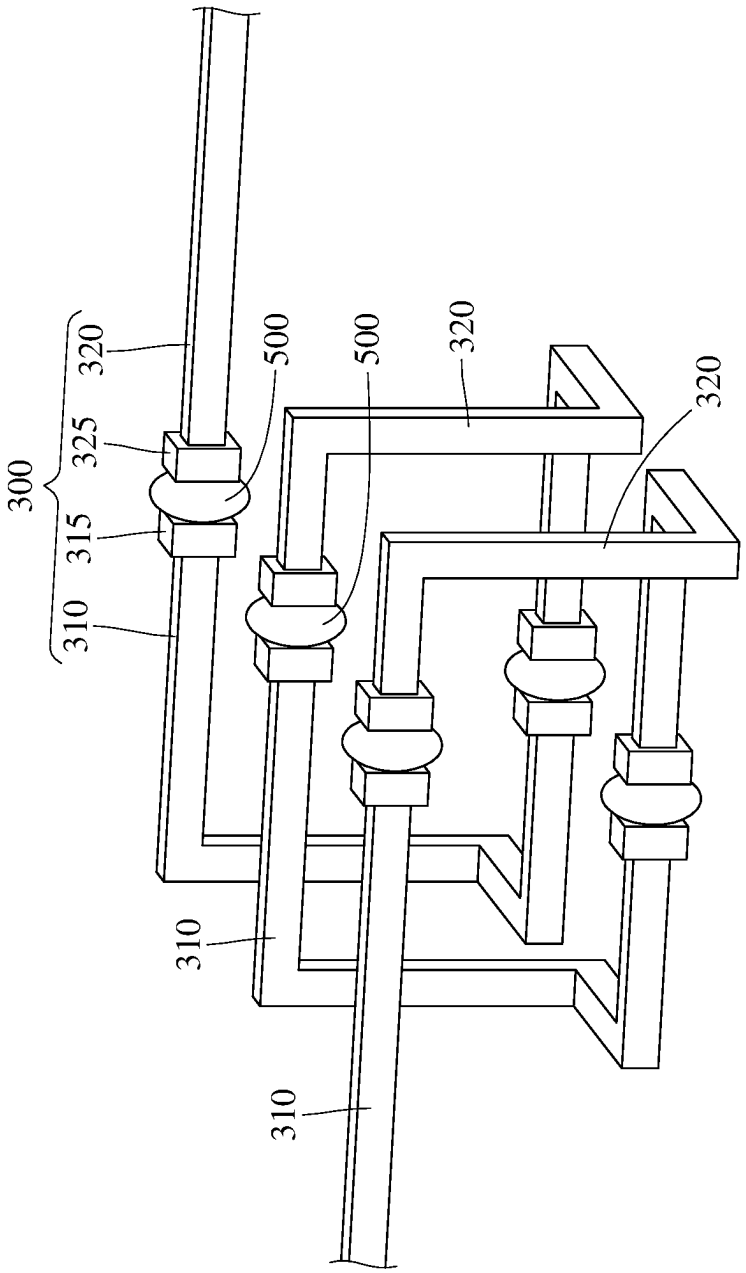
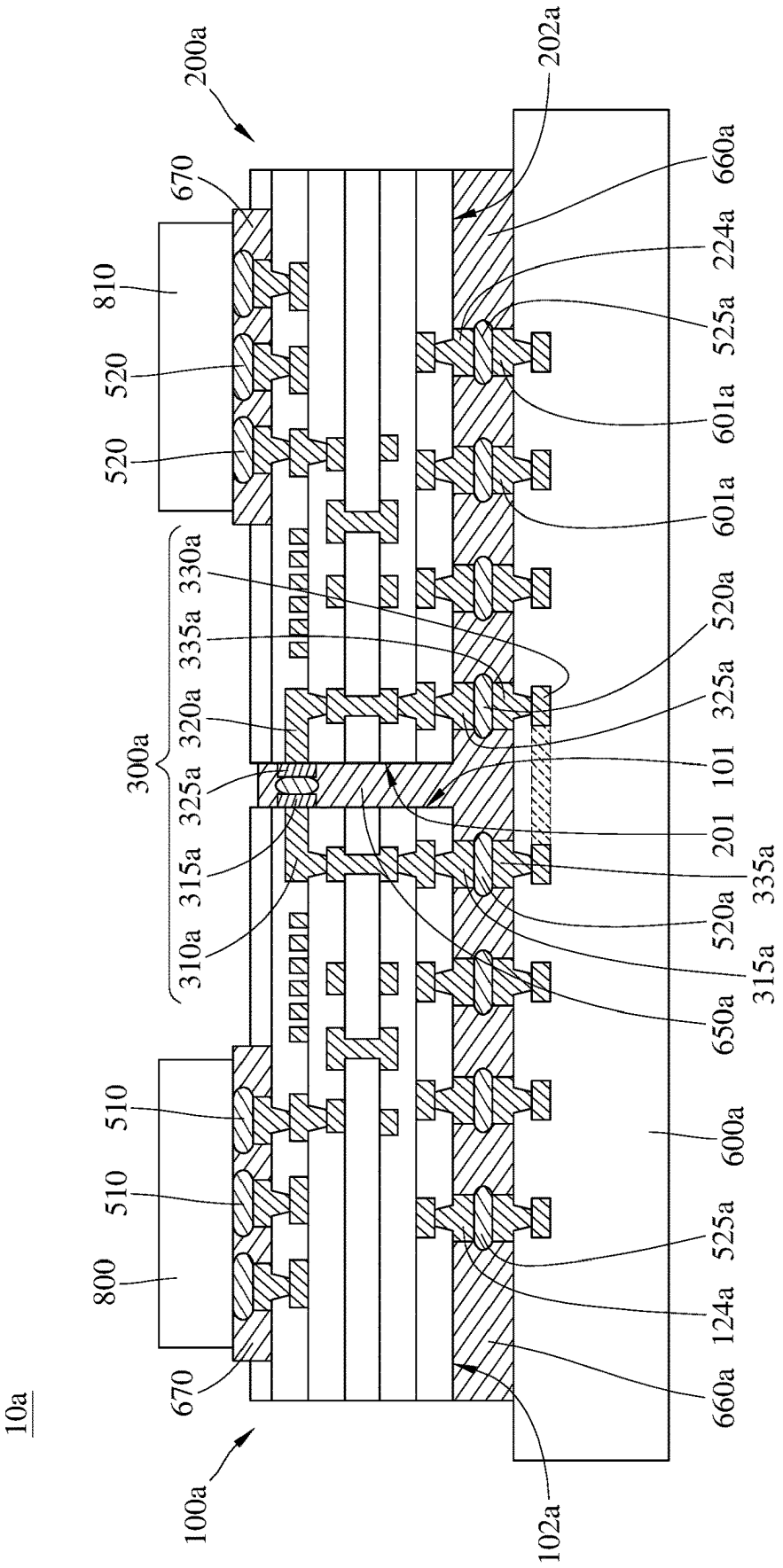


FIG. 5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601a
101
201
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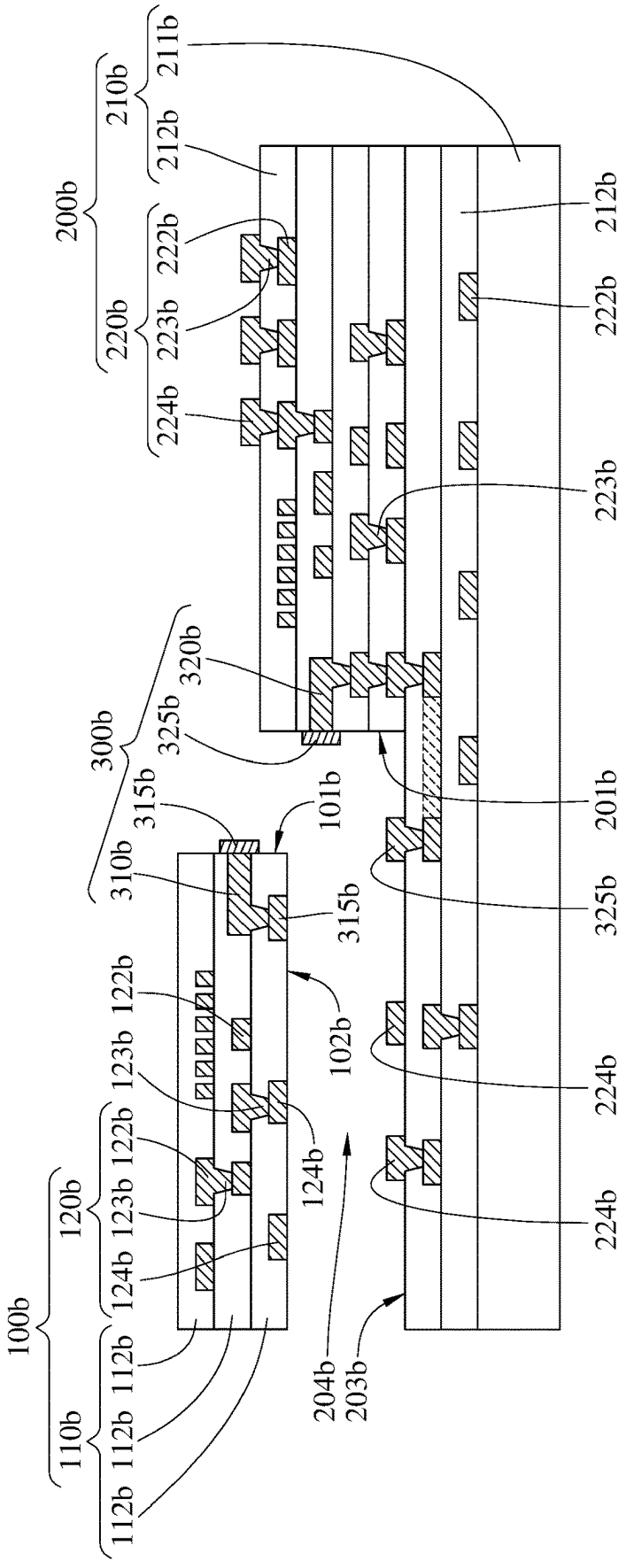
810
510
520
670

FIG. 6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112b
112b
120b
122b
123b
124b
200b
210b
211b
212b
220b
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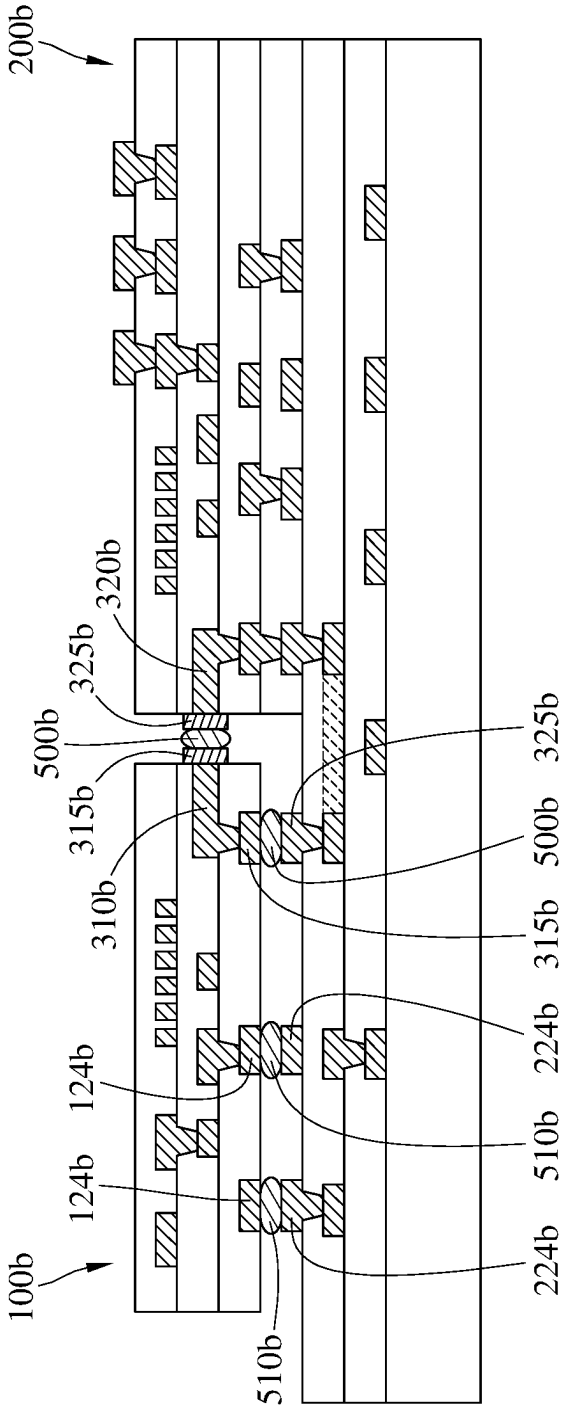
101b
102b
124b
201b
203b
204b

FIG. 7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325b
500b
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310b
124b
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100b
510b
325b
500b
315b
224b
510b
224b

FIG. 8

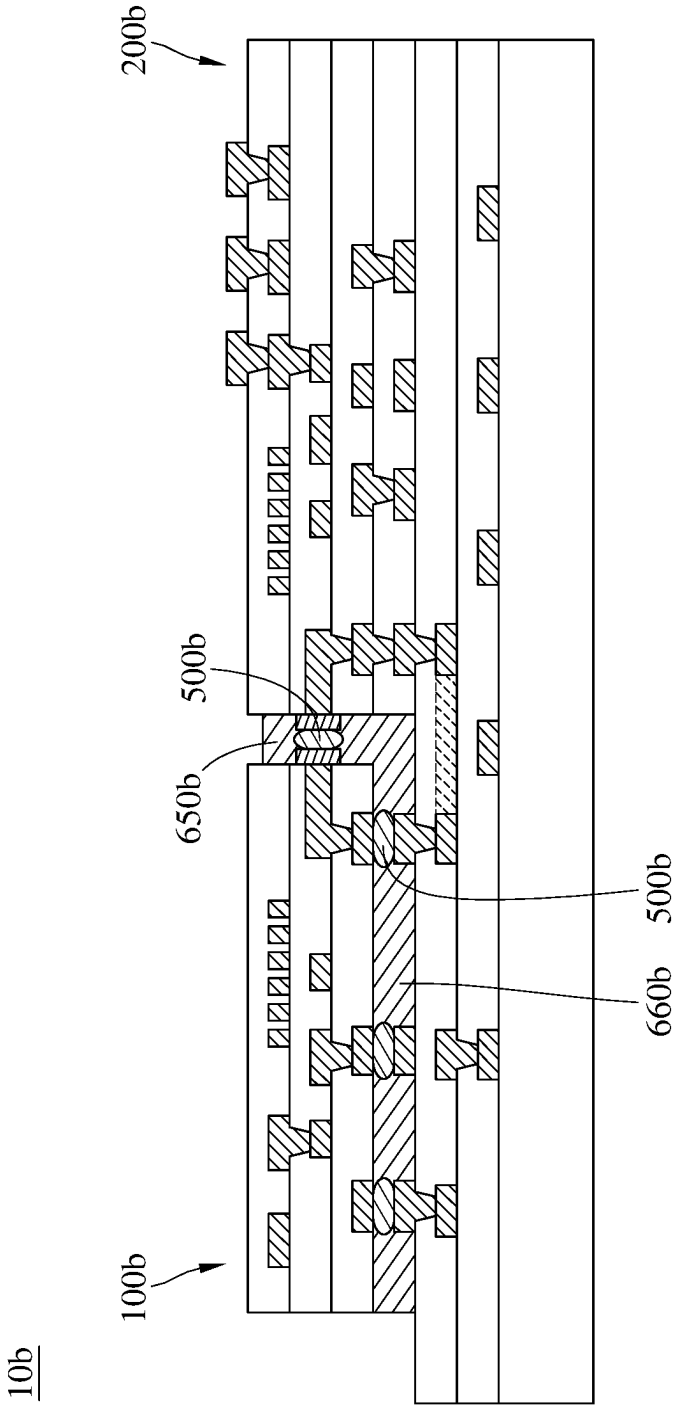
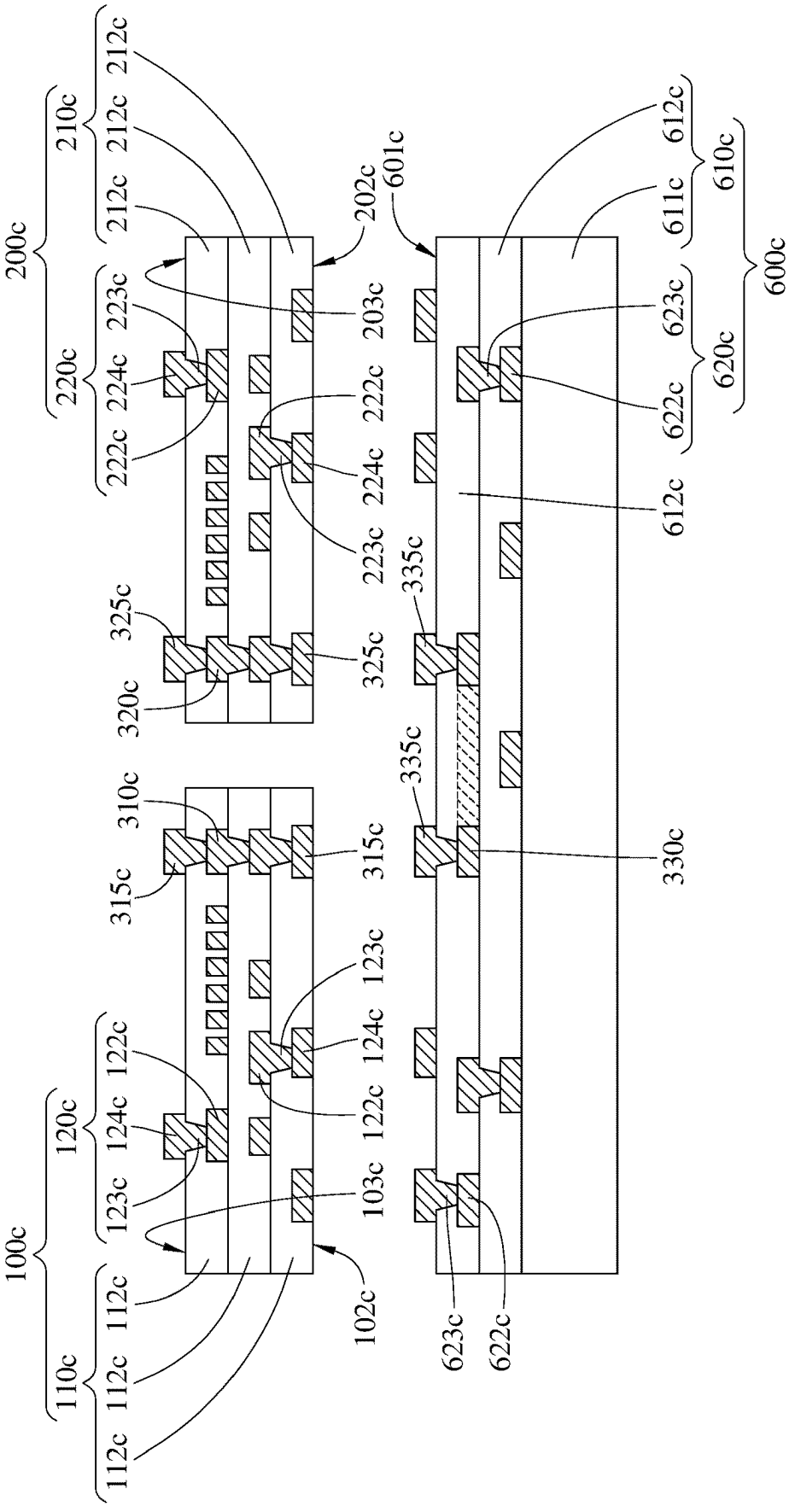


FIG. 9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103c
102c
200c
210c
212c
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220c
222c
224c
223c
203c
202c
601c
600c
610c
611c
612c
620c
622c
623c
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335c
335c
330c
315c
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223c
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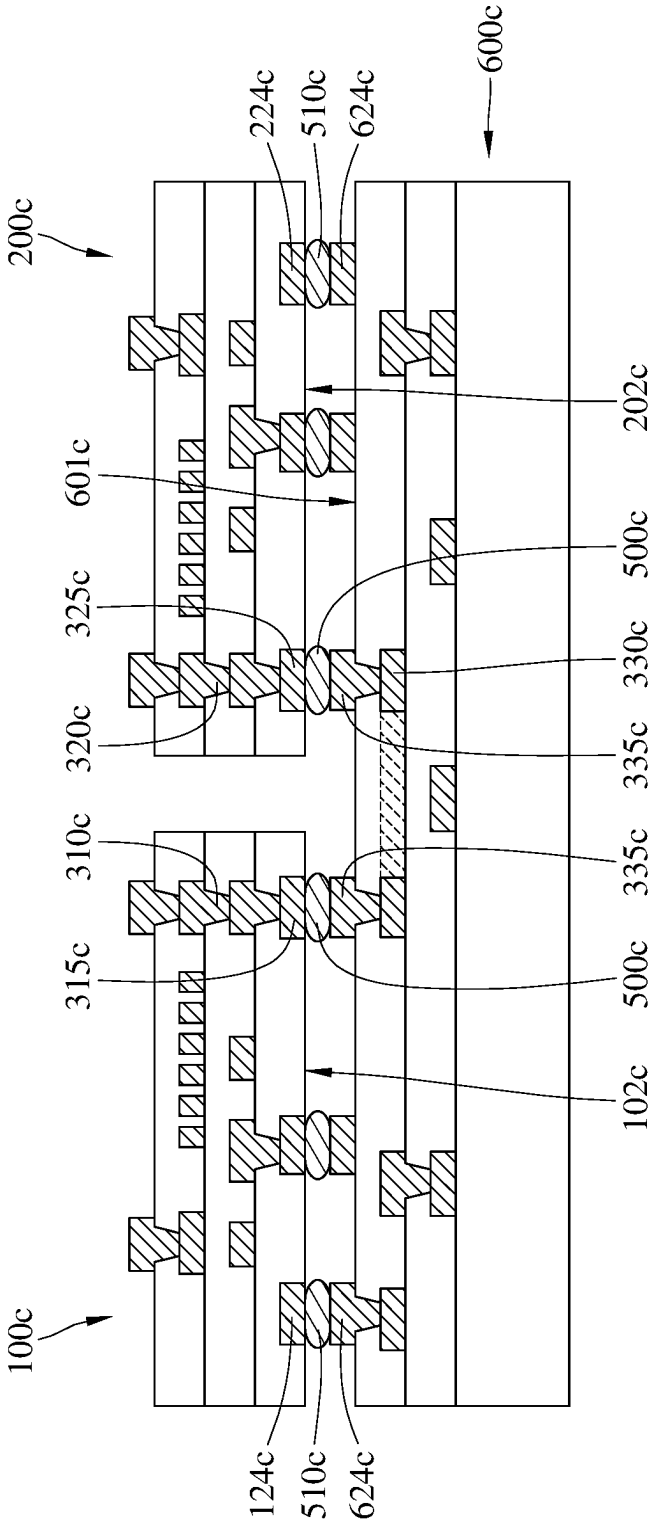
222c
123c
124c
122c
623c
622c

FIG. 10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224c
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624c
200c
202c
601c
500c
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335c
310c
335c
315c
500c
102c
100c
124c
510c
624c

FIG. 11

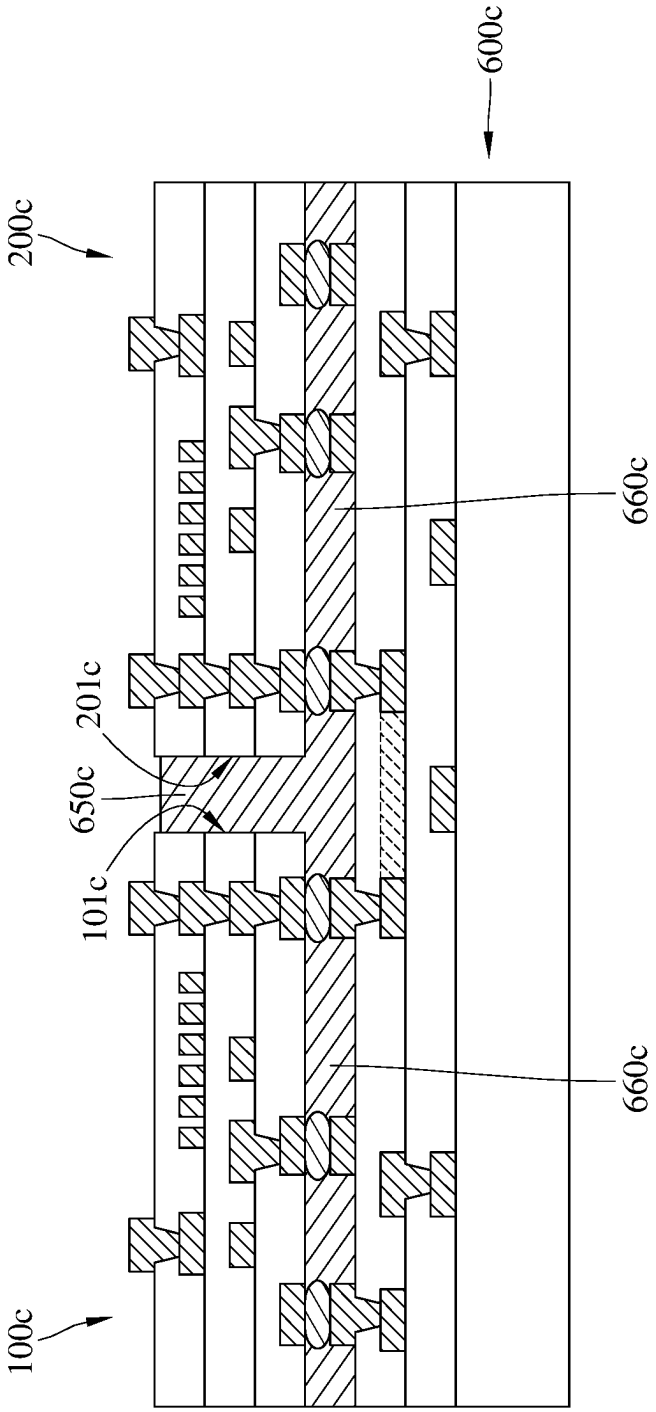
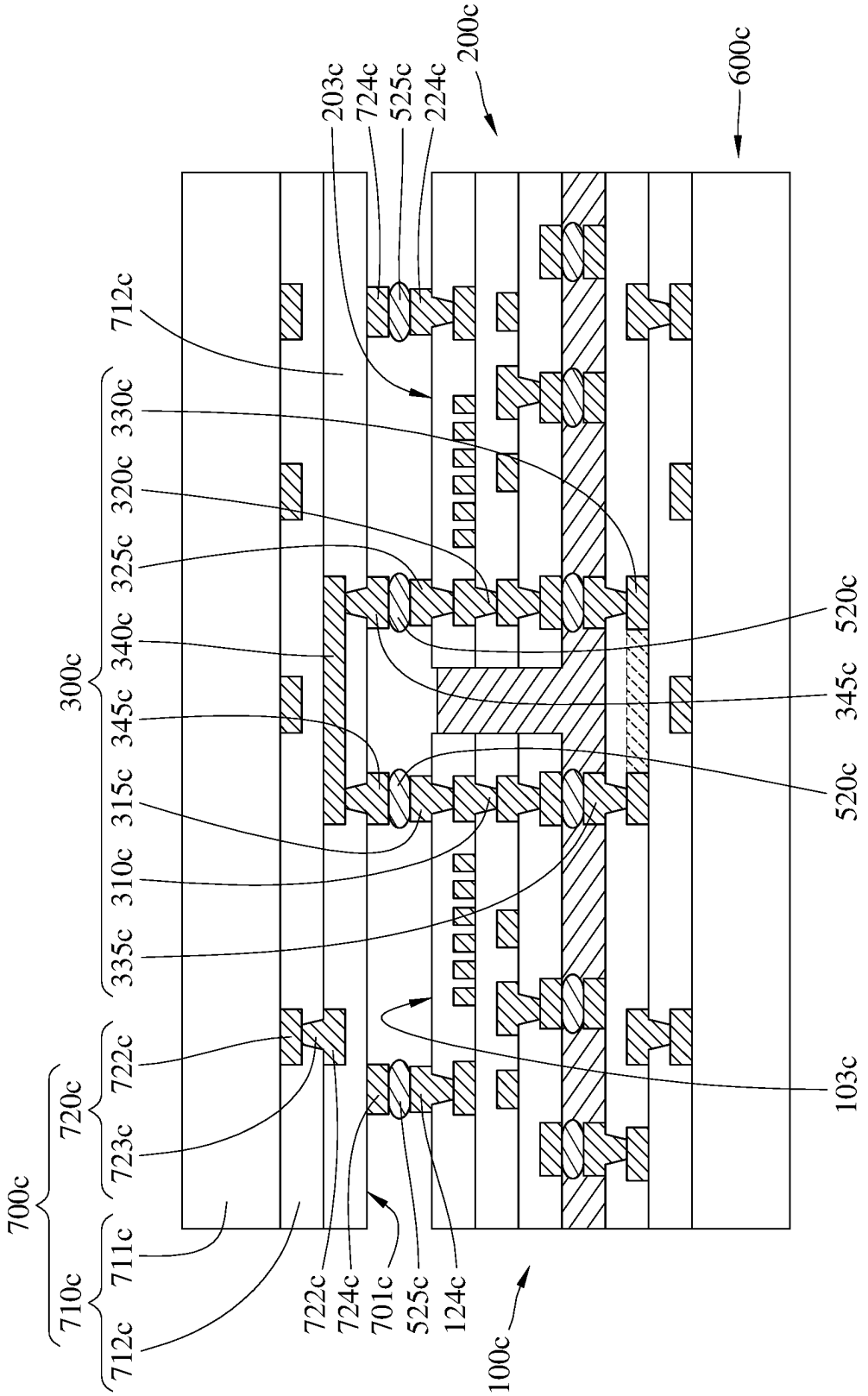


FIG. 12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600c
712c
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520c
345c
520c
103c
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FIG. 13

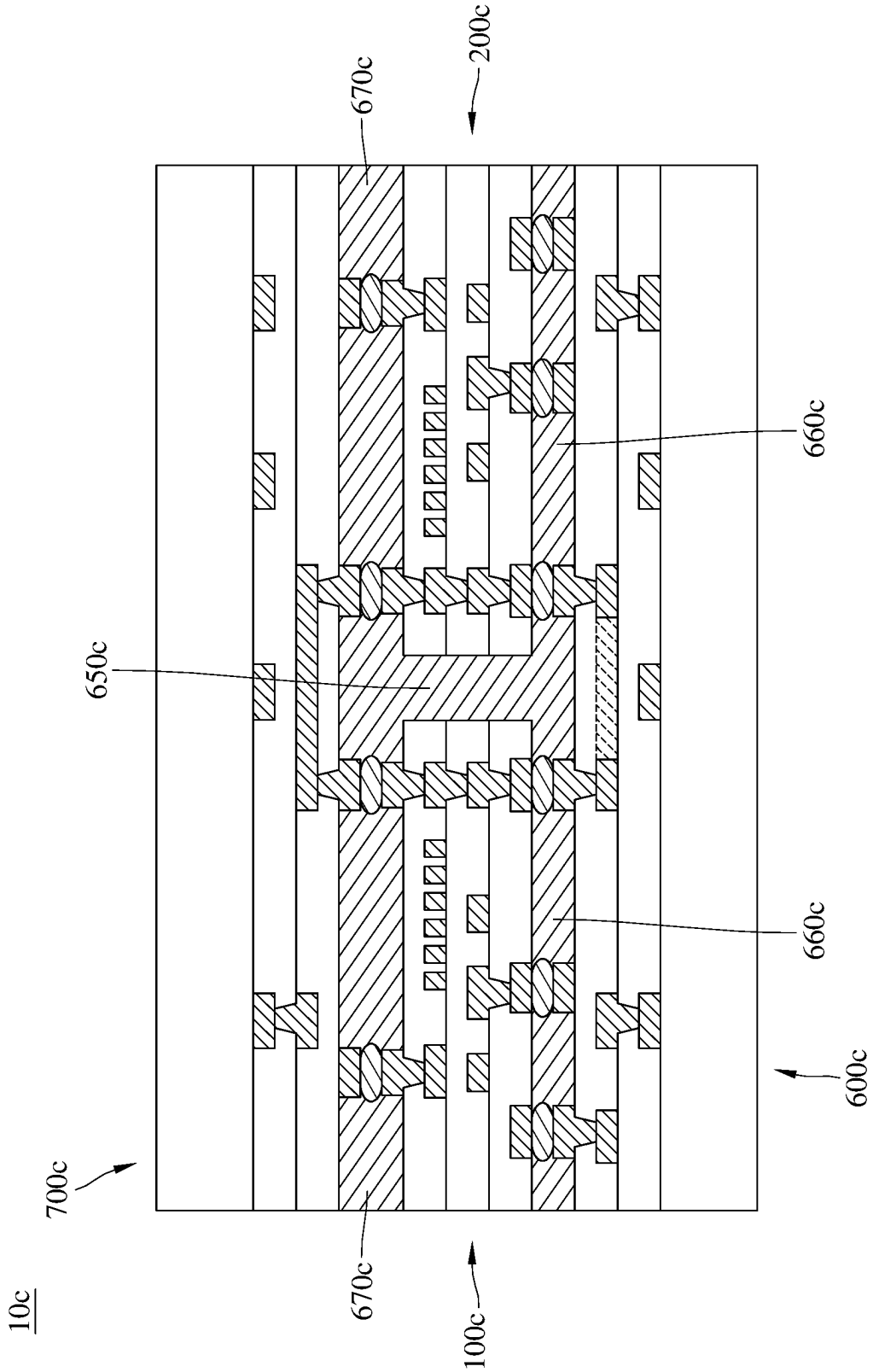

FIG. 14

CIRCUIT BOARD STRUCTURE AND MANUFACTURING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This non-provisional application claims priority under 35 U.S.C. § 119(a) on Patent Application No(s). 112117285 filed in Taiwan, R.O.C. on May 10, 2023, the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD

The disclosure relates to a circuit board structure and a manufacturing method thereof, more particularly to a circuit board structure including a conductive coil and a first molding compound and a manufacturing method thereof.

BACKGROUND

An inductor, a passive component in electronics, has multiple functions of, for example, filtering noise, suppressing momentary current, preventing interference caused by electromagnetic wave, shielding electromagnetic radiation, reducing electromagnetic interference and converting power. Thus, there is usually at least one inductor disposed in a circuit board.

In general, in order to configure an inductor, an entire of a conductive coil is formed in a single circuit board. However, the entire of the conductive coil occupies significant amount of space in the circuit board, which is unfavorable for the space utilization and the miniaturization of the circuit board.

SUMMARY

The disclosure provides a circuit board structure and a manufacturing method thereof to improve the space utilization of the circuit board and facilitate the miniaturization of the circuit board.

One embodiment of this disclosure provides a circuit board structure including a first circuit board, a second circuit board, a conductive coil and a first molding compound. The first circuit board has a first side surface. The second circuit board has a second side surface facing the first side surface and being spaced apart from the first side surface. The conductive coil is in a spiral shape and includes a first coil pattern and a second coil pattern. The first coil pattern is disposed in the first circuit board. The second coil pattern is disposed in the second circuit board. The first coil pattern is electrically connected to the second coil pattern. The first molding compound is magnetic and filled in a gap located between the first side surface and the second side surface. The conductive coil surrounds at least a part of the first molding compound.

In an embodiment of the disclosure, the circuit board structure further includes a third circuit board. The first circuit board and the second circuit board are disposed on the third circuit board.

In an embodiment of the disclosure, the conductive coil further comprises a third coil pattern disposed in the third circuit board. The first coil pattern is electrically connected to the second coil pattern via the third coil pattern.

In an embodiment of the disclosure, the circuit board structure further includes a first die and a second die. The first die is disposed on the first circuit board, and the second die is disposed on the second circuit board.

In an embodiment of the disclosure, the circuit board structure further includes a second molding compound. The second molding compound is filled in a gap located on a side of the third circuit board located closest to the first circuit board and the second circuit board.

In an embodiment of the disclosure, the circuit board structure further includes a fourth circuit board disposed on the first circuit board and the second circuit board.

In an embodiment of the disclosure, the conductive coil further includes a third coil pattern and a fourth coil pattern. The third coil pattern is disposed in the third circuit board. The fourth coil pattern is disposed in the fourth circuit board. The first coil pattern is electrically connected to the second coil pattern via the third coil pattern and the fourth coil pattern.

In an embodiment of the disclosure, the circuit board structure further includes a second molding compound and a third molding compound. The second molding compound is filled in a gap located on a side of the third circuit board located closest to the first circuit board and the second circuit board. The third molding compound is filled in a gap located on a side of the fourth circuit board located closest to the first circuit board and the second circuit board.

In an embodiment of the disclosure, the second circuit board further has a cavity. The second side surface faces the cavity. The first circuit board is located in the cavity.

In an embodiment of the disclosure, the circuit board structure further includes a second molding compound. The first circuit board further has a bottom surface. The bottom surface is located adjacent to the first side surface. The second circuit board further has a lower surface. The lower surface and the second side surface form the cavity. The second molding compound is filled in a gap located between the bottom surface of the first circuit board and the lower surface of the second circuit board.

A manufacture method of a circuit board structure according to another embodiment of the disclosure includes the following steps: forming a first coil pattern of a conductive coil in a first circuit board, forming a second coil pattern of the conductive coil in a second circuit board, electrically connecting the first coil pattern to the second coil pattern, and filling a first molding compound in a gap located between a first side surface of the first circuit board and a second side surface of the second circuit board. The first molding compound is magnetic. The conductive coil surrounds at least a part of the first molding compound.

In an embodiment of the disclosure, the manufacture method of the circuit board structure further includes disposing the first circuit board and the second circuit board on a third circuit board.

In an embodiment of the disclosure, the manufacture method of the circuit board structure further includes forming a third coil pattern of the conductive coil in the third circuit board. Electrically connecting the first coil pattern to the second coil pattern includes electrically connecting the first coil pattern to the second coil pattern via the third coil pattern.

In an embodiment of the disclosure, the manufacture method of the circuit board structure further includes disposing a fourth circuit board on the first circuit board and the second circuit board.

In an embodiment of the disclosure, the manufacture method of the circuit board structure further includes forming a third coil pattern of the conductive coil in the third circuit board, and forming a fourth coil pattern of the conductive coil in the fourth circuit board. Electrically connecting the first coil pattern to the second coil pattern

includes electrically connecting the first coil pattern to the second coil pattern via the third coil pattern and the fourth coil pattern.

According to the circuit board structure and the manufacture method thereof disclosed by above embodiments, the conductive coil is in a spiral shape and includes the first coil pattern disposed in the first circuit board and the second coil pattern disposed in the second circuit board. That is, the present disclosure respectively forms multiple coil patterns in multiple circuit boards to configure the conductive coil, thereby preventing the conductive coil from occupying significant amount of space in a single circuit board. Accordingly, the space utilization of each of the first circuit board and the second circuit board is improved, and the miniaturization of each of the first circuit board and the second circuit board is facilitated.

In addition, the magnetic first molding compound is filled in the gap between the first side surface and the second side surface, and the conductive coil surrounds at least a part of the first molding compound. Therefore, the first molding compound can enhance the inductance effect generated by the conductive coil without occupying the space in the first circuit board or the second circuit board. That is, the first molding compound enhances the inductance effect while improving the space utilization of each of the first circuit board and the second circuit board.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure will become better understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only and thus are not intending to limit the present disclosure and wherein:

FIGS. **1** to **3** are side cross-sectional views showing a manufacture method of a circuit board structure according to a first embodiment of the disclosure;

FIG. **4** is a top view of the circuit board structure according to the first embodiment of the disclosure;

FIG. **5** is a perspective view of a conductive coil of the circuit board structure in FIG. **4**;

FIG. **6** is a side cross-sectional view of a circuit board structure according to a second embodiment of the disclosure;

FIGS. **7** to **9** are side cross-sectional views showing a manufacture method of a circuit board structure according to a third embodiment of the disclosure; and

FIGS. **10** to **14** are side cross-sectional views showing a manufacture method of a circuit board structure according to a fourth embodiment of the disclosure.

DETAILED DESCRIPTION

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

Please refer to FIGS. **1** to **3**. FIGS. **1** to **3** are side cross-sectional views showing a manufacture method of a circuit board structure **10** according to a first embodiment of the disclosure. The manufacture method of the circuit board structure **10** according to this embodiment may include the following steps.

Please refer to FIG. **1**, a first coil pattern **310** of a conductive coil **300** is formed in a first circuit board **100**. The first circuit board **100** includes an insulating part **110** and a conductive part **120**. The insulating part **110** is, for example, a multi-layered structure. The insulating part **110** includes a substrate **111**, a plurality of dielectric layers **112** and two insulating material layers **113**. The dielectric layers **112** are disposed on the substrate **111**. The two insulating material layers **113** are disposed on the dielectric layers **112**. The conductive part **120** is configured to transmit or receive one or more signals, and includes a conductive through hole **121**, a plurality of wiring layers **122**, a plurality of conductive blind vias **123** and a plurality of pads **124**. The conductive through hole **121** penetrates through the substrate **111**. The wiring layers **122** are disposed on the dielectric layers **112**, respectively. The conductive blind vias **123** are located in the dielectric layers **112**, respectively. The pads **124** are disposed on top and bottom sides of the dielectric layers **112** that are opposite to each other, respectively.

In this embodiment, the first coil pattern **310** includes a plurality of vertical portions and a plurality of horizontal portions. The vertical portions of the first coil pattern **310** are formed together with the conductive through hole **121** in the substrate **111**, or formed together with the conductive blind vias **123** in each dielectric layer **112**. The horizontal portions of the first coil pattern **310** are formed together with the wiring layers **122** on each dielectric layer **112**.

In addition, a plurality of pads **315** are formed on the first coil pattern **310**. The pads **315** are located on a first side surface **101** of the first circuit board **100**.

In addition, a second coil pattern **320** of the conductive coil **300** is formed in a second circuit board **200**. The second circuit board **200** includes an insulating part **210** and a conductive part **220**. The insulating part **210** is, for example, a multi-layered structure. The insulating part **210** includes a substrate **211**, a plurality of dielectric layers **212** and two insulating material layers **213**. The dielectric layers **212** are disposed on the substrate **211**. The two insulating material layers **213** are disposed on the dielectric layers **212**. The conductive part **220** is configured to transmit or receive one or more signals, and includes a conductive through hole **221**, a plurality of wiring layers **222**, a plurality of conductive blind vias **223** and a plurality of pads **224**. The conductive through hole **221** penetrates through the substrate **211**. The wiring layer **222** are disposed on the dielectric layers **212**, respectively. The conductive blind vias **223** are located in the dielectric layers **212**, respectively. The pads **224** are disposed on top and bottom sides of the dielectric layers **212** that are opposite to each other, respectively.

In this embodiment, the second coil pattern **320** includes a plurality of vertical portions and a plurality of horizontal portions. The vertical portions of the second coil pattern **320** are formed together with the conductive through hole **221** in the substrate **211**, or formed together with or the conductive blind vias **223** in each dielectric layer **212**. The horizontal portions of the second coil pattern **320** are formed together with the wiring layers **222** on each dielectric layer **212**.

Additionally, a plurality of pads **325** are formed on the second coil pattern **320**. The pads **325** are located on a second side surface **201** of the second circuit board **200**.

Note that the present disclosure is not limited by the orders of the steps shown in the drawings. For example, with respect to the steps shown in FIG. **1**, in other embodiments, the first circuit board may be provided before the second circuit board is provided. Alternatively, the first coil pattern may be formed in the first circuit board before the second coil pattern is formed in the second circuit board. Alterna-

tively, the pads may be formed on the first coil pattern before the pads are formed on the second coil pattern. The steps in other figures are not limited by their orders based on similar reasons, and thus the repeated descriptions are omitted.

Then, please refer to FIG. **2**, the first coil pattern **310** is electrically connected to the second coil pattern **320**. In detail, the pads **315** are electrically connected to the pad **325** via, for example, a plurality of solder balls **500**, thereby electrically connecting the first coil pattern **310** to the second coil pattern **320**.

In addition, the first circuit board **100** and the second circuit board **200** are disposed on a third circuit board **600**. Also, the pads **124** and **224** are electrically connected to the third circuit board **600**.

Then, please refer to FIG. **3**, a first molding compound **650**, which is magnetic, is filled in a gap located between the first side surface **101** of the first circuit board **100** and the second side surface **201** of the second circuit board **200**. Also, a second molding compound **660** is filled in a gap located on a side of the third circuit board **600** that is located closest to the first circuit board **100** and the second circuit board **200**. That is, the second molding compound **660** is filled in a gap located between the third circuit board **600** and the first circuit board **100** and a gap located between the third circuit board **600** and the second circuit board **200**. In this embodiment, the first molding compound **650** is spaced apart from the second molding compound **660**.

In addition, a first die **800** is disposed on the first circuit board **100**, and a second die **810** is disposed on the second circuit board **200**. The first die **800** is electrically connected to the pads **124** of the first circuit board **100** via, for example, solder balls **510**. The second die **810** is electrically connected to the pads **224** of the second circuit board **200** via, for example, solder balls **520**. Also, a die molding compound **670** is filled in, for example, a gap located between the first die **800** and the dielectric layers **112** of the first circuit board **100** and a gap located between the second die **810** and the dielectric layers **212** of the second circuit board **200**. Manufacturing of the circuit board structure **10** is completed so far.

In addition, in this embodiment, the second molding compound **660** and the die molding compound **670** are, for example, magnetic, but the disclosure is not limited thereto. In other embodiments, the second molding compound and the die molding compound may not be magnetic. That is, the molding compounds except the first molding compound filled in the gap located between the first side surface of the first circuit board and the second side surface of the second circuit board, may not be magnetic.

Please refer to FIGS. **3** to **5**. FIG. **4** is a top view of the circuit board structure **10** according to the first embodiment of the disclosure. FIG. **5** is a perspective view of the conductive coil **300** of the circuit board structure **10** in FIG. **4**. In this embodiment, the conductive coil **300** is in a spiral shape, and surrounds at least a part of the first molding compound **650**. In addition, in order to illustrate the spiral shape of the conductive coil **300**, FIG. **5** shows the conductive coil **300** with simplified shape. In practical, the vertical portions of the first coil pattern **310** and the second coil pattern **320** in FIG. **5** may be similar to the conductive through holes **121** and **221** or the conductive blind vias **123** and **223** in shape. Also, the horizontal portions of the first coil pattern **310** and the second coil pattern **320** in FIG. **5** may be similar to the wiring layers **122** and **222** in shape. As shown in FIG. **5**, the conductive coil **300** has, for example, three turns, but the disclosure is not limited thereto. In other embodiments, the conductive coil may merely have a single turn.

In addition, the disclosure is not limited by the arranging direction of the turns of the conductive coil **300**. In other embodiments, as long as the conductive coil surrounds at least a part of the first molding compound, the turns of the conductive coil are allowed to be arranged along an arbitrary direction.

In this disclosure, the first circuit board **100** and the second circuit board **200** are respectively formed in the first coil pattern **310** and the second coil pattern **320** to configure the conductive coil **300**. Thus, the space of the first circuit board **100** or the second circuit board **200** occupied by the conductive coil **300** is reduced. In this way, the space utilization of each of the first circuit board **100** and the second circuit board **200** is improved, and the miniaturization of each of the first circuit board **100** and the second circuit board **200** is facilitated.

In addition, the magnetic first molding compound **650** is filled in the gap located between the first side surface **101** and the second side surface **201**, and the conductive coil **300** surrounds at least a part of the first molding compound **650**. Therefore, the first molding compound **650** can enhance the inductance effect generated by the conductive coil **300** without occupying the space in the first circuit board **100** or the second circuit board **200**. That is, the first molding compound **650** enhances the inductance effect while improving the space utilization of each of the first circuit board **100** and the second circuit board **200**.

Other embodiments are described below for illustrative purposes. It is to be noted that the following embodiments use the reference numerals and a part of the contents of the above embodiments, the same reference numerals are used to denote the same or similar elements, and the description of the same technical contents is omitted. For the description of the omitted part, reference may be made to the above embodiments, and details are not described in the following embodiments.

The structure of the conductive coil may be adjusted according to the demand of the inductance effect for each circuit board. For example, please refer to FIG. **6**. FIG. **6** is a side cross-sectional view of a circuit board structure **10*a*** according to a second embodiment of the disclosure. The main difference between the circuit board structure **10*a*** of this embodiment and the circuit board structure **10** of the first embodiment is the structure of a conductive coil **300*a***. Comparing to the first embodiment, a third circuit board **600*a*** of this embodiment has higher demand for the inductance effect due to the demand of, for example, stabilizing voltage by removing magnetic fields. Thus, comparing to the first embodiment, the conductive coil **300*a*** further includes a third coil pattern **330*a*** and a plurality of pads **335*a*** electrically connected to the third coil pattern **330*a***. The third coil pattern **330*a*** is disposed in the third circuit board **600*a***.

The first coil pattern **310*a*** is electrically connected to the second coil pattern **320*a*** via the third coil pattern **330*a***. In detail, in this embodiment, the pads **315*a*** are located on the first side surface **101** and a bottom surface **102*a*** of the first circuit board **100*a***, respectively. The bottom surface **102*a*** is located adjacent to the first side surface **101**. Similarly, the pads **325*a*** are located on the second side surface **201** and a bottom surface **202*a*** of the second circuit board **200*a***, respectively. The bottom surface **202*a*** is located adjacent to the second side surface **201**. The pad **315*a*** located on the first side surface **101** is electrically connected to the pad

325*a* located on the second side surface **201**. The pad **315***a* located on the bottom surface **102***a* and the pad **325***a* located on the bottom surface **202***a* are electrically connected to the pads **335***a* via, for example, a plurality of solder balls **520***a*. Also, the pads **124***a* of the first circuit board **100***a* and the pads **224***a* of the second circuit board **200***a* are electrically connected to the pads **601***a* of the third circuit board **600***a* via, for example, a plurality of solder balls **525***a*. Additionally, in this embodiment, the first molding compound **650***a* is connected to the second molding compound **660***a*.

Note that the circuit board structure is not limited to include the third circuit board. The circuit board structure may merely include the first circuit board and the second circuit board without including the third circuit board. For example, please refer to FIGS. **7-9**. FIGS. **7** to **9** are side cross-sectional views showing a manufacture method of a circuit board structure **10***b* according to a third embodiment of the disclosure. The manufacture method of the circuit board structure **10***b* may include following steps:

Please refer to FIG. **7**, a first coil pattern **310***b* of a conductive coil **300***b* is formed in a first circuit board **100***b*. The first circuit board **100***b* includes an insulating part **110***b* and a conductive part **120***b*. The insulating part **110***b* is, for example, a multi-layered structure. The insulating part **110***b* includes a plurality of dielectric layers **112***b*. The conductive part **120***b* is configured to transmit or receive one or more signals, and includes a plurality of wiring layers **122***b*, a plurality of conductive blind vias **123***b* and a plurality of pads **124***b*. The wiring layers **122***b* are disposed on the dielectric layers **112***b*, respectively. The conductive blind vias **123***b* are located in the dielectric layers **112***b*, respectively. The pads **124***b* are located on a side of the dielectric layers **112***b*. The first coil pattern **310***b* is formed in the first circuit board **100***b* in a manner similar to the first coil pattern **310** in the first circuit board **100**, and thus the repeated descriptions are omitted.

In addition, a plurality of pads **315***b* are formed on the first coil pattern **310***b*. The pads **315***b* are located on a first side surface **101***b* and a bottom surface **102***b* of the first circuit board **100***b*, respectively. The bottom surface **102***b* is located adjacent to the first side surface **101***b*.

Furthermore, a second coil pattern **320***b* of the conductive coil **300***b* is formed in a second circuit board **200***b*. The second circuit board **200***b* includes an insulating part **210***b* and a conductive part **220***b*. The insulating part **210***b* is, for example, a multi-layered structure. The insulating part **210***b* includes a substrate **211***b* and a plurality of dielectric layers **212***b*. The dielectric layers **212***b* are disposed on the substrate **211***b*. The conductive part **220***b* is configured to transmit or receive one or more signals, and includes a plurality of wiring layers **222***b*, a plurality of conductive blind vias **223***b* and a plurality of pads **224***b*. The wiring layers **222***b* are disposed on the dielectric layers **212***b*, respectively. The conductive blind vias **223***b* are located in the dielectric layers **212***b*, respectively. The pads **224***b* are located on a side of the dielectric layers **212***b*. The second coil pattern **320***b* is formed in the second circuit board **200***b* in a manner similar to the second coil pattern **320** in the second circuit board **200**, and thus the repeated descriptions are omitted.

In addition, a plurality of pads **325***b* are formed on the second coil pattern **320***b*. The pads **325***b* are located on a second side surface **201***b* and a lower surface **203***b* of the second circuit board **200***b*, respectively.

In this embodiment, a size of the first circuit board **100***b* is, for example, smaller than a size of the second circuit board **200***b*. The second circuit board **200***b* has a cavity **204***b*. The cavity **204***b* is formed by the second side surface **201***b* and the lower surface **203***b*. The first circuit board **100***b* is located in the cavity **204***b*.

Please refer to FIG. **8**, the first coil pattern **310***b* is electrically connected to the second coil pattern **320***b*. In detail, the pads **315***b* are electrically connected to the pads **325** via, for example, a plurality of solder balls **500***b*, thereby electrically connecting the first coil pattern **310***b* to the second coil pattern **320***b*. In addition, the pads **124***b* of the first circuit board **100***b* are electrically connected to the pads **224***b* of the second circuit board **200***b* via, for example, a plurality of solder balls **510***b*.

Please refer to FIG. **9**, a first molding compound **650***b* that is magnetic is filled in a gap located between the first side surface **101***b* of the first circuit board **100***b* and the second side surface **201***b* of the second circuit board **200***b*. Also, a second molding compound **660***b* is filled in a gap located between the bottom surface **102***b* of the first circuit board **100***b* and the lower surface **203***b* of the second circuit board **200***b*. Manufacturing of the circuit board structure **10***b* is completed so far. In this embodiment, the first molding compound **650***b* is connected to the second molding compound **660***b*. Note that in this embodiment, the first molding compound **650***b* and the second molding compound **660***b* are sequentially filled, but the disclosure is not limited thereto. In other embodiments, in order to facilitate the manufacture process, the first molding compound may be simultaneously filled in both the gap located between the first side surface of the first circuit board and the second side surface of the second circuit board and the gap located between the bottom surface of the first circuit board and the recessed surface of the second circuit board, and the second molding compound may be omitted herein.

The circuit board structure is not limited to include two or three circuit boards. The circuit board structure may include four or more circuit boards. For example, please refer to FIGS. **10** to **14**. FIGS. **10** to **14** are side cross-sectional views showing a manufacture method of a circuit board structure **10***c* according to a fourth embodiment of the disclosure. The manufacture method of the circuit board structure **10***c* of this embodiment may include following steps:

Please refer to FIG. **10**, a first coil pattern **310***c* is formed in a first circuit board **100***c*. The first circuit board **100***c* includes an insulating part **110***c* and a conductive part **120***c*. The insulating part **110***c* is, for example, a multi-layered structure. The insulating part **110***c* includes a plurality of dielectric layers **112***c*. The conductive part **120***c* is configured to transmit or receive one or more signals, and includes a plurality of wiring layers **122***c*, a plurality of conductive blind vias **123***c* and a plurality of pads **124***c*. The wiring layers **122***c* are disposed on the dielectric layers **112***c*, respectively. The conductive blind vias **123***c* are located in the dielectric layers **112***c*, respectively. The pads **124***c* are located on top and bottom sides of the dielectric layers **112***c* that are opposite to each other, respectively. The first coil pattern **310***c* is formed in the first circuit board **100***c* in a manner similar to the first coil pattern **310** in the first circuit board **100**, and thus the repeated descriptions are omitted.

In addition, a plurality of pads **315***c* are formed on the first coil pattern **310***c*. The pads **315***c* are located on a bottom surface **102***c* and a top surface **103***c* of the first circuit board **100***c*, respectively. The bottom surface **102***c* faces away from the top surface **103***c*.

Additionally, a second coil pattern **320***c* is formed in a second circuit board **200***c*. The second circuit board **200***c* includes an insulating part **210***c* and a conductive part **220***c*. The insulating part **210***c* is, for example, a multi-layered

structure. The insulating part **210***c* includes a plurality of dielectric layers **212***c*. The conductive part **220***c* is configured to transmit or receive one or more signals, and includes a plurality of wiring layers **222***c*, a plurality of conductive blind vias **223***c* and a plurality of pads **224***c*. The wiring layers **222***c* are disposed on the dielectric layers **212***c*, respectively. The conductive blind vias **223***c* are located in the dielectric layers **212***c*, respectively. The pads **224***c* are located on top and bottom sides of the dielectric layers **212***c* that are opposite to each other, respectively. The second coil pattern **320***c* is formed in the second circuit board **200***c* in a manner similar to the second coil pattern **320** in the second circuit board **200**, and thus the repeated descriptions are omitted.

Furthermore, a plurality of pads **325***c* are formed on the second coil pattern **320***c*. The pads **325***c* are located on a bottom surface **202***c* and a top surface **203***c* of the second circuit board **200***c*, respectively. The bottom surface **202***c* faces away from the top surface **203***c*.

Moreover, a third coil pattern **330***c* is formed in a third circuit board **600***c*. The third circuit board **600***c* includes an insulating part **610***c* and a conductive part **620***c*. The insulating part **610***c* is, for example, a multi-layered structure. The insulating part **610***c* includes a substrate **611***c* and a plurality of dielectric layers **612***c*. The dielectric layers **612***c* are disposed on the substrate **611***c*. The conductive part **620***c* is configured to transmit or receive one or more signals, and includes a plurality of wiring layers **622***c* and a plurality of conductive blind vias **623***c*. The wiring layers **622***c* are disposed on the dielectric layers **612***c*, respectively. The conductive blind vias **623***c* are located in the dielectric layers **612***c*, respectively. The third coil pattern **330***c* is formed in the third circuit board **600***c* in a manner similar to the first coil pattern **310** in the first circuit board **100** or the second coil pattern **320** in the second circuit board **200**, and thus the repeated descriptions are omitted.

Further, a plurality of pads **335***c* are formed on the third coil pattern **330***c*. The pads **335***c* are located on a top surface **601***c* of the third circuit board **600***c*. The top surface **601***c* faces the first circuit board **100***c* and the second circuit board **200***c*.

Please refer to FIG. **11**, the first circuit board **100***c* and the second circuit board **200***c* are disposed on the third circuit board **600***c*. Also, the first coil pattern **310***c* and the second coil pattern **320***c* are electrically connected to the third coil pattern **330***c*. In detail, the pads **315***c* and **325***c* located on the bottom surfaces **102***c* and **202***c* are electrically connected to the pads **335***c* via, for example, a plurality of solder balls **500***c*, thereby electrically connecting the first coil pattern **310***c* and the second coil pattern **320***c* to the third coil pattern **330***c*. Also, the pads **124***c* of the first circuit board **100***c* and the pads **224***c* of the second circuit board **200***c* are electrically connected to the pads **624***c* of the third circuit board **600***c* via, for example, a plurality of solder balls **510***c*.

Please refer to FIG. **12**, a first molding compound **650***c*, which is magnetic, is filled in a gap located between a first side surface **101***c* of the first circuit board **100***c* and a second side surface **201***c* of the second circuit board **200***c*. Also, a second molding compound **660***c* is filled in a gap located on a side of the third circuit board **600***c* that is located closest to the first circuit board **100***c* and the second circuit board **200***c*. That is, the second molding compound **660***c* is filled in a gap located between the first circuit board **100***c* and the third circuit board **600***c*, and a gap located between the second circuit board **200***c* and the third circuit board **600***c*. The first side surface **101***c* connects the bottom surface **102***c* and the top surface **103***c*. The second side surface **201***c* connects the bottom surface **202***c* and the top surface **203***c*.

Please refer to FIG. **13**, a fourth coil pattern **340***c* is formed in a fourth circuit board **700***c*. The fourth circuit board **700***c* is disposed on the first circuit board **100***c* and the second circuit board **200***c*. The fourth circuit board **700***c* includes an insulating part **710***c* and a conductive part **720***c*. The insulating part **710***c* is, for example, a multi-layered structure. The insulating part **710***c* includes a substrate **711***c* and a plurality of dielectric layers **712**. The substrate **711***c* is disposed on the dielectric layers **712***c*. The conductive part **720***c* is configured to transmit or receive one or more signals, and includes a plurality of wiring layers **722***c* and a conductive blind via **723***c*. The wiring layers **722***c* are disposed on the dielectric layers **712***c*, respectively. The conductive blind via **723***c* is located in the dielectric layers **712***c*. The fourth coil pattern **340***c* is formed in the fourth circuit board **700***c* in a manner similar to the first coil pattern **310** in the first circuit board **100** or the second coil pattern **320** in the second circuit board **200**, and thus the repeated descriptions are omitted.

In addition, a plurality of pads **345***c* are formed on the fourth coil pattern **340***c*. The pads **345***c* are located on a bottom surface **701***c* of the fourth circuit board **700***c*. The bottom surface **701***c* faces the first circuit board **100***c* and the second circuit board **200***c*.

Moreover, the first coil pattern **310***c* and the second coil pattern **320***c* are electrically connected to the fourth coil pattern **340***c*. In detail, the pads **315***c* and **325***c* located on the top surfaces **103***c* and **203***c* are electrically connected to the pads **345***c* via, for example a plurality of solder balls **520***c*, thereby electrically connecting the first coil pattern **310***c* and the second coil pattern **320***c* to the fourth coil pattern **340***c*. In this way, the first coil pattern **310***c* is electrically connected to the second coil pattern **320***c* via the third coil pattern **330***c* and the fourth coil pattern **340***c*. Also, the pads **124***c* of the first circuit board **100***c* and the pads **224***c* of the second circuit board **200***c* are electrically connected to the pads **724***c* of the fourth circuit board **700***c* via, for example, a plurality of solder balls **525***c*. Manufacturing of a conductive coil **300***c* including the first coil pattern **310***c*, the second coil pattern **320***c*, the third coil pattern **330***c*, the fourth coil pattern **340***c* and the pads **315***c*, **325***c*, **335***c* and **345***c* is completed so far.

Please refer to FIG. **14**, a third molding compound **670***c* is filled in a gap located on a side of the fourth circuit board **700***c* located closest to the first circuit board **100***c* and the second circuit board **200***c*. That is, the third molding compound **670***c* is filled in a gap located between the first circuit board **100***c* and the fourth circuit board **700***c* and a gap located between the second circuit board **200***c* and the fourth circuit board **700***c*. Manufacturing of the circuit board structure **10***c* is completed so far. In this embodiment, the first molding compound **650***c*, the second molding compound **660***c* and the third molding compound **670***c* are connected to one another.

According to the circuit board structure and the manufacture method thereof disclosed by above embodiments, the conductive coil is in a spiral shape and includes the first coil pattern disposed in the first circuit board and the second coil pattern disposed in the second circuit board. That is, the present disclosure respectively forms multiple coil patterns in multiple circuit boards to configure the conductive coil, thereby preventing the conductive coil from occupying significant amount of space in a single circuit board. Accordingly, the space utilization of each of the first circuit board

and the second circuit board is improved, and the miniaturization of each of the first circuit board and the second circuit board is facilitated.

In addition, the magnetic first molding compound is filled in the gap between the first side surface and the second side surface, and the conductive coil surrounds at least a part of the first molding compound. Therefore, the first molding compound can enhance the inductance effect generated by the conductive coil without occupying the space in the first circuit board or the second circuit board. That is, the first molding compound enhances the inductance effect while improving the space utilization of each of the first circuit board and the second circuit board.

It will be apparent to those skilled in the art that various modifications and variations can be made to the present disclosure. It is intended that the specification and examples be considered as exemplary embodiments only, with a scope of the disclosure being indicated by the following claims and their equivalents.

What is claimed is:

1. A circuit board structure, comprising:

a first circuit board, having a first side surface, wherein a normal direction of the first side surface is perpendicular to a thickness direction of the first circuit board;

a second circuit board, having a second side surface facing the first side surface and being spaced apart from the first side surface, wherein a normal direction of the second side surface is perpendicular to a thickness direction of the second circuit board;

a conductive coil, in a spiral shape and comprising a first coil pattern and a second coil pattern, wherein the first coil pattern is disposed in the first circuit board, the second coil pattern is disposed in the second circuit board, and the first coil pattern is electrically connected to the second coil pattern; and

a first molding compound, being magnetic and filled in a gap located between the first side surface and the second side surface, wherein the conductive coil surrounds at least a part of the first molding compound;

wherein the first coil pattern is exposed to the gap from the first side surface and the second coil pattern is exposed to the gap from the second side surface.

2. The circuit board structure according to claim **1**, further comprising a third circuit board, wherein the first circuit board and the second circuit board are disposed on the third circuit board.

3. The circuit board structure according to claim **2**, wherein the conductive coil further comprises a third coil pattern disposed in the third circuit board, and the first coil pattern is electrically connected to the second coil pattern via the third coil pattern.

4. The circuit board structure according to claim **2**, further comprising a first die and a second die, wherein the first die is disposed on the first circuit board, and the second die is disposed on the second circuit board.

5. The circuit board structure according to claim **3**, further comprising a first die and a second die, wherein the first die is disposed on the first circuit board, and the second die is disposed on the second circuit board.

6. The circuit board structure according to claim **2**, further comprising a second molding compound, wherein the second molding compound is filled in a gap located on a side of the third circuit board located closest to the first circuit board and the second circuit board.

7. The circuit board structure according to claim **3**, further comprising a second molding compound, wherein the second molding compound is filled in a gap located on a side of the third circuit board located closest to the first circuit board and the second circuit board.

8. The circuit board structure according to claim **2**, further comprising a fourth circuit board disposed on the first circuit board and the second circuit board.

9. The circuit board structure according to claim **8**, wherein the conductive coil further comprises a third coil pattern and a fourth coil pattern, the third coil pattern is disposed in the third circuit board, the fourth coil pattern is disposed in the fourth circuit board, and the first coil pattern is electrically connected to the second coil pattern via the third coil pattern and the fourth coil pattern.

10. The circuit board structure according to claim **8**, further comprising a second molding compound and a third molding compound, wherein the second molding compound is filled in a gap located on a side of the third circuit board located closest to the first circuit board and the second circuit board, and the third molding compound is filled in a gap located on a side of the fourth circuit board located closest to the first circuit board and the second circuit board.

11. The circuit board structure according to claim **1**, wherein the second circuit board further has a cavity, the second side surface faces the cavity, and the first circuit board is located in the cavity.

12. The circuit board structure according to claim **11**, further comprising a second molding compound, wherein the first circuit board further has a bottom surface, the bottom surface is located adjacent to the first side surface, the second circuit board further has a lower surface, the lower surface and the second side surface form the cavity, and the second molding compound is filled in a gap located between the bottom surface of the first circuit board and the lower surface of the second circuit board.

13. A manufacture method of a circuit board structure, comprising: forming a first coil pattern of a conductive coil in a spiral shape, in a first circuit board; forming a second coil pattern of the conductive coil in a spiral shape, in a second circuit board; electrically connecting the first coil pattern to the second coil pattern; and filling a first molding compound in a gap located between a first side surface of the first circuit board having a normal direction perpendicular to a thickness direction of the first circuit board and a second side surface of the second circuit board having a normal direction perpendicular to a thickness direction of the second circuit board, wherein the first molding compound is magnetic, and the conductive coil surrounds at least a part of the first molding compound, and wherein the first coil pattern is exposed to the gap from the first side surface and the second coil pattern is exposed to the gap from the second side surface.

14. The manufacture method of the circuit board structure according to claim **13**, further comprising:

disposing the first circuit board and the second circuit board on a third circuit board.

15. The manufacture method of the circuit board structure according to claim **14**, further comprising:

forming a third coil pattern of the conductive coil in the third circuit board;

wherein, electrically connecting the first coil pattern to the second coil pattern comprises electrically connecting the first coil pattern to the second coil pattern via the third coil pattern.

16. The manufacture method of the circuit board structure according to claim **14**, further comprising:

disposing a fourth circuit board on the first circuit board and the second circuit board.

17. The manufacture method of the circuit board structure according to claim 16, further comprising:

forming a third coil pattern of the conductive coil in the third circuit board; and

forming a fourth coil pattern of the conductive coil in the fourth circuit board;

wherein, electrically connecting the first coil pattern to the second coil pattern comprises electrically connecting the first coil pattern to the second coil pattern via the third coil pattern and the fourth coil pattern.

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