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MULTILAYER CIRCUIT BOARD AND
METHOD FOR MANUFACTURING MULTILAYER CIRCUIT BOARD

BACKGROUND OF THE INVENTION

The present invention relates to a multilayer circuit board
5 and a method for manufacturing the multilayer circuit board,
especially relates to a multilayer circuit board that has electrodes,
which are used for the connection with a chip component; only on
one surface of the board and to a method for manufacturing the
multilayer circuit board.

10 A conventionally known multilayer circuit board of the same
type is manufactured using a plurality of so-called double-sided
boards as follows. Each double-sided board includes a
thermosetting resin film and a plurality of conductor layers, which
are located on two surfaces of the thermosetting resin film. The
15 conductor layers on one surface are electrically connected to the
conductor layers on the other surface. The plurality of
double-sided boards are piled with a plurality of interconnecting
boards, which include unset thermosetting resin films in B stage
and are ready for electrically connecting the conductor layers, such
20 that the interconnecting boards are interleaved with the
double-sided boards. At the same time, an unset thermosetting resin
film is piled to cover one surface, to which the chip component is
not connected, of the piled body, which includes the interconnecting
boards and the double-sided boards. Then, the piled body, which
25 includes the interconnecting boards, the double-sided boards, and
the unset thermosetting resin film, is pressed and heated to complete



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the conventionally known multilayer circuit board.

Another conventionally known multilayer circuit board is manufactured as follows. An interconnecting board and a conductive foil are piled in this order on each surface of a double-sided board.

5 After the piled body, which includes the double-sided board, the interconnecting boards, and the conductive foils, is pressed and heated, the conductive foils formed on both surfaces of the double-sided board are shaped by etching. An intermediate multilayer circuit board having the predetermined number of layers
10 is formed by repeating a series of the piling, pressing, heating, and etching steps. After an unset thermosetting resin film is piled with the intermediate multilayer circuit board to cover one surface of the board, the piled body, which includes the intermediate multilayer circuit board and the unset thermosetting resin film,
15 is pressed and heated to complete the another conventionally known multilayer circuit board.

In the methods for manufacturing conventionally known multilayer circuit boards described above, after a plurality of double-sided boards and a plurality of interconnecting boards are
20 formed separately, the two are combined together, or after one double-sided board and a plurality of interconnecting boards are formed separately, they are combined with the conductive foils and. Therefore, the manufacturing process is relatively complicated.

SUMMARY OF THE INVENTION

25 The present invention has been made in view of the above aspects with an object to provide a multilayer circuit board, the

manufacturing process of which can be simplified even if the multilayer circuit board has electrodes used for connection with a chip component only on one surface of the board, and to provide a method for manufacturing the multilayer circuit board.

5 A plurality of conductor layers are formed on a resin film made of thermoplastic resin to form a single-sided conductor layer film. Then, a plurality of via-holes, which are bottomed by the conductor layers, are formed in the single-sided conductor layer film. Then an interlayer connecting material is packed in the
10 via-holes to form a single-sided conductor layer film having the interlayer connecting material. A plurality of single-sided conductor layer films are formed and stacked such that surfaces having the conductor layers face in the same direction. Then, the single-sided conductor layer films are pressed and heated to
15 complete the multilayer circuit board, which has electrodes only on one surface. The multilayer circuit board is formed by using only the single-sided conductor layer films and pressing once, so the manufacturing process is simplified.

BRIEF DESCRIPTION OF THE DRAWINGS

20 The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

 Figs. 1A to 1F are step-by-step cross-sectional views showing
25 the summarized production process of a multilayer circuit board according to the first embodiment of the present invention; and

Figs. 2A to 2F are step-by-step cross-sectional views showing the summarized production process of a multilayer circuit board according to the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 The present invention will be described in detail with reference to various embodiments.

First Embodiment

As shown in Fig. 1A, a single-sided conductor layer film 21 has conductor layers 22, which are shaped by etching a conductive
10 foil (a copper foil with a nominal thickness of 18 micrometers in this embodiment) adhered onto one side of a resin film 23. In Fig. 1A, a thermoplastic film with a thickness of 25 - 75 micrometers, which is made of a mixture of 65 - 35 weight% polyetheretherketone resin and 35 - 65 weight% polyetherimide resin, is used as the resin
15 film 23.

After the conductor layers 22 are formed as shown in Fig. 1A, to form a single-sided conductor layer film 31 having electrodes 33, which is described later, a single-sided conductor layer film 21 is immersed in plating solutions for so-called nickel-gold
20 plating. Surfaces of the conductor layers 22 are plated with nickel and gold, and as shown in Fig. 1B, processed surface layers 32 are formed on the surfaces of the conductor layers 22. The processed surface layers 32 are formed for the purpose of improving the adhesion with a bonding material such as solder when a chip component
25 is connected to the electrodes 33 by the bonding material.

After the conductor layers 22 are formed as shown in Fig. 1A,

via-holes 24, which are bottomed by the conductor layers 22, are formed in the single-sided conductor layer film 21 by irradiating with carbon dioxide laser from the side of the resin film 23, as shown in Fig. 1C. When the via-holes 24 is formed, the conductor layers 22 escape being dug by adjusting the power and the exposure time period of the carbon dioxide laser. Other than the carbon dioxide laser, excimer laser and so on may be used for forming the via-holes 24. Other than laser, via-hole formation means such as drilling is applicable. However, if holes are machined by laser beam, it is possible to form holes with a fine diameter and the conductor layers 22 incur less damage, so laser beam is preferred.

After the via-hole 24 are formed as shown in Fig. 1C, then, conductive paste 50 (interlayer connecting material), which is a material for electric connection, is packed in the via-holes 24, as shown in Fig. 1D. The conductive paste 50 is prepared as follows. An organic solvent and binder resin are added to metal particles made of copper, silver, tin, and so on. The mixture is compounded by a mixer to make it pasty. The conductive paste 50 is printed and packed in the via-holes 24 by a screen-printing machine. Instead of the method using the screen-printing machine, other methods using a dispenser and so on may be used as long as the conductive paste 50 is surely packed in the via-holes 24. Although not illustrated, with respect to the single-sided conductor layer film 31 shown in Fig. 1B, the via-holes 24 are formed and the conductive paste 50 is packed by the same steps as in Figs. 1C and 1D.

After the conductive paste 50 is packed in the via-holes 24

of the single-sided conductor layer films 21, 31, as viewed in Fig. 1E, a plurality of single-sided conductor layer films 21 (three films in Fig. 1E) are stacked such that the surfaces having the conductor layers 22 face upward. On top of the stacked single-sided conductor layer films 21, the single-sided conductor layer film 31, which includes the electrodes 33, is stacked such that the surface having the electrodes 33 faces upward. No via-holes are formed in the single-sided conductor layer film 21 that is located at the lowest position in Fig. 1E.

After the single-sided conductor layer films 21, 31 are stacked to form a stacked body as shown in Fig. 1E, the stacked body in Fig. 1E is pressed and heated from the top and the bottom surfaces of the stacked body by a vacuum hot-press machine. Specifically, the stacked body in Fig. 1E is pressed under a pressure of 1 - 10 MPa while being heated at a temperature of 250 - 350 °C to bond the single-sided conductor layer films 21, 31 and to form an integrated body, as shown in Fig. 1F. All the resin films 23 are made of the same thermoplastic resin and the modulus of elasticity of the resin films 23 is reduced to about 5 - 40 MPa when being pressed and heated by the vacuum hot-press machine, so the resin films 23 are readily heat-sealed and integrated, as shown in Fig. 1F. Moreover, the surface activities of the conductor layers 22 and the conductive paste 50 in the via-holes 24 are increased by being heated above 250 °C, so the conductor layers 22 and the conductive paste 50 are connected and a plurality of pairs of conductor layers 22, which are separated by the resin films 23, are electrically connected by the conductive paste 50. With above steps, a multilayer circuit

board 100, which includes the electrodes 33 only on one surface of the board 100, is manufactured.

In the method according to the first embodiment, the modulus of elasticity of the resin films 23 while being pressed and heated is preferably 1 - 1000 MPa. If the modulus of elasticity is greater than 1000 MPa, it is difficult to heat-seal the resin films 23 and the conductor layers 22 are readily broken by excessive stress that the conductor layers 22 incur while being pressed and heated. On the other hand, if the modulus of elasticity is smaller than 1 MPa, the resin films 23 flow readily and the conductor layers 22 are drifted too readily to form the multilayer circuit board 100.

In the method according to the first embodiment, the multilayer circuit board 100 is manufactured using only the single-sided conductor layer films 21, 31, so the manufacturing process can be simplified. Moreover, the single-sided conductor layer films 21, 31 are bonded together at one time by being pressed and heated once. Therefore, it is possible to shorten the lead time in the manufacturing process and simplify further the manufacturing process. In addition, the surface, to which the chip component is not connected, of the multilayer circuit board 100 is insulated by the resin film 23 of the single-sided conductor layer film 21 that is located at the lowest position as viewed in Fig. 1E. Therefore, no dedicated insulating layer made of a film and so on is needed.

Second Embodiment

Using steps shown in Figs. 2A-2D, which are the same steps as those shown in Figs. 1A-1D in the first embodiment, the conductor layers 22 are formed on the resin films 23, the processed surface

layers 32 and the via-holes 24 are formed in the resin films 23, and the conductive paste 50 is packed in the via-holes 24. A plurality of single-sided conductor layer films 21a are formed using the same steps as for the single-sided conductor layer films 21.

5 Each single-sided conductor layer film 21a includes a plurality of thermal vias 44, which are made of via-holes 24a and the conductive paste 50, which is packed in the via-holes 24a.

After the conductive paste 50 is packed in the via-holes 24, 24a of the single-sided conductor layer films 21, 21a, 31, as shown

10 in Fig. 2E, a plurality of single-sided conductor layer films 21, 21a (three films in this embodiment) are stacked such that the surfaces having the conductor layers 22 face upward. On top of the stacked single-sided conductor layer films 21, 21a, the single-sided conductor layer film 31, which includes the electrodes 33, is stacked

15 such that the surface having the electrodes 33 faces upward.

As viewed in Fig. 2E, a heat sink 46 made of aluminum alloy is placed under the stacked body that includes single-sided conductor layer films 21, 21a, 31. The heat sink 46 is a heat releasing member and has a roughened surface at the upper side of

20 the heat sink 46 in Fig. 2E for the purpose of improving the adhesion, which is described later, when being bonded to the single-sided conductor layer film 21a. As a method for forming the roughened surface, buffing, shot blasting, anodic oxide coating, and so on may be employed.

25 After the stacked body and the heat sink 46 are stacked as shown in Fig. 2E, the stacked body and the heat sink 46 are pressed and heated by the vacuum hot-press machine. By being pressed and

heated, the single-sided conductor layer films 21, 21a, 31 and the heat sink 46 are bonded together, and an integrated body is formed, as shown in Fig. 2F. The resin films 23 are heat-sealed and integrated, and at the same time a plurality of pairs of conductor
5 layers 22, which are separated by the resin films 23, are electrically connected by the conductive paste 50 in the via-holes 24, 24a, and a multilayer circuit board 100, which includes the electrodes 33 only on one surface of the board 100, is manufactured. As viewed in Fig. 2F, the heat sink 46 is located on the bottom surface
10 of the board 100, and the bottom surface faces in the direction opposite to the one in which the top surface having the electrodes 33 faces.

In Fig. 2E, the via-holes 24a are located at the central areas of two single-sided conductor layer films 21a. The conductive paste
15 50 packed in the via-holes 24a of the two single-sided conductor layer films 21a are directly or indirectly connected to the heat sink 46, as shown in Fig. 2F. Specifically, the conductive paste 50 of one single-sided conductor layer film 21a to which the heat sink 46 is connected is directly connected to the heat sink 46 and
20 connects the heat sink 46 and the conductor layers 22 of the one single-sided conductor layer film 21a is connected. The conductive paste 50 of the other single-sided conductor layer film 21a connects the conductor layers 22 of the one single-sided conductor layer film 21a and the conductor layers 22 of the other single-sided conductor
25 layer film 21a.

As shown in Fig. 2F, via-holes 24a and the conductive paste 50 packed in the via-holes 24a of the two single-sided conductor

layer films 21a make up thermal vias 44. A plurality of thermal vias 44 are formed for releasing heat from the integrated single-sided conductor layer films 21, 21a, 31 to the heat sink 46. In the method according to the second embodiment, the thermal vias 5 44 and the conductor layers 22 connected to the thermal vias 44 in Fig. 2F are electrically insulated from other conductor layers 22 that make up an electric circuit in the multilayer circuit board 100. The conductive paste 50 of the thermal vias 44 is formed only for the thermal conduction to the heat sink 46. The electric circuit 10 of the multilayer circuit board 100 is insulated at the surface having the heat sink 46.

The via-holes 24a of the thermal vias 44 are formed to have the same diameter (nominally 100 micrometers in Figs. 2E and 2F) as other via-holes 24. The thermal conductivity of the thermal vias 15 44 can be improved by increasing the diameter of the via-holes 24a of the thermal vias 44 and the connecting material 50 packed in the via-holes 24a. However, the adhesion between the multilayer circuit board 100 and the heat sink 46 extremely decreases at the positions where the thermal vias 44 are formed. On the other hand, 20 if the number of the thermal vias 44 is increased without increasing the diameter to improve the thermal conductivity, the adhesion between the multilayer circuit board 100 and the heat sink 46 can be prevented from decreasing.

The resin films 23 are made of the same thermoplastic resin, 25 and the modulus of elasticity of the resin films 23 is reduced to about 5 - 40 MPa when being pressed and heated by the vacuum hot-press machine. In addition, the surface activities of the conductor

layers 22, the conductive paste 50, and the heat sink 46 are increased by being heated above 250 °C. Therefore, the resin films 23 can be surely bonded to each other, and the conductor layers 22, the conductive paste 50, and the heat sink 46 can be surely connected
5 to each other. The modulus of elasticity of the resin films 23 while being pressed and heated is preferably 1 - 1000 MPa because of the same reasons as described in the first embodiment.

In the method according to the second embodiment, the multilayer circuit board 100 is formed using only the single-sided
10 conductor layer films 21, 21a, 31, so the manufacturing process can be simplified. Moreover, the single-sided conductor layer films 21, 21a, 31 are bonded together at one time by being pressed and heated once, at the same time, the heat sink 46 is connected to the multilayer circuit board 100, and the thermal vias 44 are connected
15 to the heat sink 46. Therefore, it is possible to shorten the lead time in the manufacturing process and simplify further the manufacturing process

The heat sink 46 is vulnerable to damage from the plating solutions for plating nickel and gold on the conductor layers 22
20 to form the electrodes 33. Therefore, the heat sink 46 needs to be protected by coating resin and so on if the heat sink 46 has to be immersed in the plating solutions to form the processed surface layers 32 on the conductive layers 22. However, in the method according to the second embodiment, the processed surface layers
25 32 are formed before the single-sided conductor layer film 21, 21a, 31, and the heat sink 46 are stacked. Therefore, there is no need to protect the heat sink 46.

Modifications

For the multilayer circuit boards 100 according to the first and second embodiments, the resin films made of a mixture of 65 - 35 weight% polyetheretherketone resin and 35 - 65 weight% polyetherimide resin are used for the resin films 23. Not being limited to the resin films, it is possible to use other resin films made by adding nonconductive filler to polyetheretherketone resin and polyetherimide resin. It is also possible to use separately polyetheretherketone or polyetherimide.

Moreover, thermoplastic resins such as thermoplastic polyimide or what is called liquid crystal polymer are usable as well. As long as a resin film has a modulus of elasticity of 1 - 1000 MPa at the heating temperature while the single-sided conductor layer films 21, 21a, 31 are pressed and heated and has thermal resistance needed at the later soldering step and so on, the resin film is preferably used.

In the multilayer circuit boards 100 according to the first and second embodiments, the processed surface layers 32 are located only on the conductor layers 22 of one single-sided conductor layer film 31, as shown in Figs. 1F and 2F. However, they may be located on the conductor layers 22 of other single-sided conductor layer films 21, 21a. Instead of the nickel-gold plating, which is applied to the conductor layers 22 to form the electrodes 33 and improve the adhesion of the bonding material that is used when the chip component is connected, heat-stable prefluxing, palladium plating and so on may be applied. If sufficient adhesion is provided without the processed surface layers 32, there is no need to form the

processed surface layers 32.

In the multilayer circuit board 100 according to the second embodiment, the heat sink 46 is made of aluminum alloy. However, it may be made of other metals or ceramics. Although the thermal
5 vias 44 are formed only in two single-sided conductor layer films 21a in Fig. 2E, there are other variations. For example, the thermal vias 44 may be formed in four single-sided conductor layer films 21a such that the thermal vias 44 are connected together to reach the top surface on which the electrodes 33 are formed to relatively
10 efficiently release heat in the chip component connected to the electrodes 33 to the heat sink 46. Not being electrically insulated from the conductor layers 22 that make up the electric circuit in the multilayer circuit board 100, the thermal vias 44 may function as a part of the electric circuit. For example, in the case that
15 the heat sink 46 is made of copper alloy and has ground potential, the thermal vias 44 may function as a wiring that electrically connects the electric circuit to the heat sink 46 to earth the electric circuit.

In the case that the heat sink 46 is an insulator made of a
20 material such as ceramics, even if the thermal vias 46 are electrically connected to the electric circuit, the electric circuit can be insulated by the heat sink 46 while desired heat releasing characteristics are assured. Although the heat sink 46 is directly connected to the single-sided conductor layer films 21a in the
25 multilayer circuit board 100, a so-called bonding sheet such as a polyetherimide sheet, a thermosetting resin sheet containing heat conductive filler, or a thermoplastic resin sheet containing heat

conductive filler may be formed on the surface of the heat sink 46, at which the heat sink 46 is adhered to the single-sided conductor layer films 21a, in order to improve adhesion or heat conductivity. However, in the case that the heat sink 46 functions as a part of
5 the electric circuit in combination with the thermal vias 44, the bonding sheet needs to be removed at the positions where the thermal vias 44 contact the heat sink 46.

The multilayer circuit boards 100 according to the first and second embodiments include four single-sided conductor layer films
10 21, 21a, 31. However, as a matter of course, the total number of the single-sided conductor layer films 21, 21a, 31 is not limited.

WHAT IS CLAIMED IS:

1. A multilayer circuit board (100) comprising an integrated body including a plurality of single-sided conductor layer films (21, 21a, 31), wherein each single-sided conductor layer film (21, 21a, 31) includes:

a resin film (23) made of thermoplastic resin; and

a plurality of conductor layers (22), which are located only on one surface of the resin film (23), wherein at least one of the single-sided conductor layer films (21, 21a, 31) includes:

a plurality of via-holes (24, 24a); and

an interlayer connecting material (50), which is located in the via-holes (24, 24a) and is in contact with the conductor layers (22), wherein the surfaces on which the conductor layers (22) are located face substantially in the same direction, and wherein electrodes (33) that include the conductor layers (22) are located only one surface of the integrated body.

2. The multilayer circuit board (100) in claim 1, wherein each electrode (33) includes a processed surface layer (32) for improving adhesion between the electrodes (33) and a bonding material, which is used for bonding a chip component to the electrodes (33).

3. The multilayer circuit board (100) in claim 1 or claim 2 including a heat releasing member (46), which is in contact with a surface of the integrated body, wherein the surface faces in a direction substantially opposite to the same direction.

4. The multilayer circuit board (100) in claim 3, wherein one of the single-sided conductor layer films (21a), which is in contact with the heat releasing member (46), includes the interlayer connecting material (50), which is in contact with the heat releasing member (46), and wherein heat is transmitted from the integrated body to the heat releasing member (46) through the interlayer connecting material (50).

5. The multilayer circuit board (100) in claim 4, wherein the interlayer connecting material (50) is electrically insulated from the conductor layers (22) that make up an electric circuit in the integrated body.

6. The multilayer circuit board (100) in claim 4, wherein the interlayer connecting material (50) is electrically in contact with the conductor layers (22) that make up an electric circuit in the integrated body.

7. A method for manufacturing a multilayer circuit board (100) comprising steps of:

stacking a plurality of single-sided conductor layer films (21, 21a, 31) to form a stacked body including the single-sided conductor layer films (21, 21a, 31), wherein each single-sided conductor layer film (21, 21a, 31) includes:

a resin film (23) made of thermoplastic resin; and

a plurality of conductor layers (22), which are located only on one surface of the resin film (23), wherein at least one of the

single-sided conductor layer films (21, 21a, 31) includes:

a plurality of via-holes (24, 24a); and

an interlayer connecting material (50), which is packed in the via-holes (24, 24a) and is in contact with the conductor layers (22), wherein the single-sided conductor layer films (21, 21a, 31) are stacked such that the surfaces on which the conductor layers (22) are located face substantially in the same direction; and

integrating the stacked single-sided conductor layer films (21, 21a, 31) by pressing and heating the stacked body to form an integrated body including the single-sided conductor layer films (21, 21a, 31) after the step of stacking, wherein a plurality of electrodes (33) including the conductor layers (22) are formed only on one surface of the integrated body.

8. The method in claim 7, wherein the stacked body is heated at a temperature, at which the thermoplastic resin has elastic modulus of 1 - 1000 MPa, at the step of integrating.

9. The method in claim 7 or claim 8 including a step of forming a processed surface layer (32) on a surface of one of the conductor layers (22) included in the electrodes (33) for improving adhesion between the electrodes (33) and a bonding material, which is used for bonding a chip component to the electrodes (33), before the step of stacking.

10. The method in any of claims 7 to 9, wherein the interlayer connecting material (50) is conductive paste (50), and wherein two

of the conductor layers (22), which are separated by one of the resin films (23) in the stacked body, are electrically connected by the conductive paste (50) by pressing and heating the stacked body at the step of integrating.

11. The method in any of claims 7 to 10, wherein a heat releasing member (46) is stacked on a surface of the stacked body at the step of stacking, wherein the surface faces in a direction substantially opposite to the same direction, and wherein the heat releasing member (46) is pressed and heated with the stacked body at the step of integrating.

12. The method in claim 11, wherein a plurality of thermal vias (44), which include the interlayer connecting material (50), are formed in one of the single-sided conductor layer films (21a), to which the heat releasing member (46) is connected, wherein interlayer connecting material (50) of the thermal vias (44) is connected to the heat releasing member (46) at the step of integrating to transmit heat from the integrated body to the heat releasing member (46) through the interlayer connecting material (50) of the thermal vias (44).

13. The method in claim 12, wherein the interlayer connecting material (50) of the thermal vias (44) is conductive paste (50) and wherein the conductor layers (22) in the single-sided conductor layer film (21a) to which the heat releasing member (46) is connected are thermally connected to the heat releasing member (46) with the

conductive paste (50) of the thermal vias (44) at the step of integrating.