

~~Method for producing a printed circuit board and a printed circuit board.~~

Process for manufacturing

The invention relates to a method for producing a printed circuit board (PCB) with at least two layers in accordance with the precharacterising part of Claim 1. The present invention further relates to a printed circuit board having at least two layers, in accordance with the precharacterising part of Claim 7.

5 Printed circuit boards having two or more conductor layers which are interconnected by means of through-connections, are used on a large scale in the electronics industry. Printed circuit boards having at least three layers are designated multilayer printed circuit boards or multilayers.

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In order to produce electrically conductive connections between the individual conductor layers of multilayer printed circuit boards, methods are known for the electro-chemical metallisation (plating) of previously drilled or punched holes. This type of through-hole plating is normally used only in the case of epoxy resin glass

15 laminates and is technically very complex, and hence expensive.

In the case of two-layer printed circuit boards consisting of base materials which are copper-clad on both sides, it is known for the electrically conductive connection of conductor tracks on both sides to be produced by pressing an electrically conductive paste into previously drilled holes. The conductive paste is subsequently
20 cured under the influence of relatively high temperatures. This method suffers from insufficient reliability of the through-hole connection.

DE-A-1,540,249, EP-A2-0,137,279 and FR-A-1,464,288 each disclose methods in which a further, relatively thin printed circuit board layer consisting of a base material layer with a ready-etched conductor pattern is applied into a support plate.
25 The electrically conductive connection of the contact areas or connecting areas of the individual levels takes place by soldering, through-hole connecting taking place only in the region of the leads of component parts. In consequence, the practical usefulness of the method is limited.

A similar method is disclosed in US-A-3,052,823, the laminate-on second or further printed circuit layer having openings in order to obtain access to the relevant contact areas of the conductor layer located underneath. The through-connecting takes place by means of soldering in the edge regions of these openings, it being possible to
5 connect contact points or connecting points which lie side-by-side directly, that is to say without the aid of connecting wires. This method provides sufficient reliability only in the case of band soldering, so that large-scale industrial use could not be implemented.

DE-B1-1,923,199 discloses a method for producing a circuit board having at least two conductor layers which are separated from one another by insulating layers,
10 in which method the conductor layers are interconnected at points by means of contact spots, which are coated for example with solder, through openings in the insulating layers. The through-connecting takes place by subjecting the contact areas to selective pressure, the outer layer being pressed onto the inner layer and being connected thereto. US-A-4,319,708 also discloses a similar method. These methods are extremely complex
15 and do not permit the production of high density multilayer circuit boards.

In EP-A-0,146,241 a description is given of a multilayer printed circuit board. Conductor tracks consisting of a conductive resin mixture are provided on the opposing surfaces of at least two base materials and on an intermediate base material. Said base material is punched in specific locations and all base materials are
20 subsequently thermolaminated. As a result, a multilayer printed circuit board without raised portions and external base material on both sides is obtained. However, said technique is unsuitable for use with metallic conductor tracks.

Finally, DE-A1-3,152,603 (EP-A1-0,067,231) discloses a method of the generic type in which an insulation coating which leaves the contact areas free is
25 initially applied to a support plate having a first conductor layer and contact areas. A copper foil is laminated onto this insulation coating, via an adhesive coating, the adhesive coating and the copper foil having holes at the points where the contact areas of the first conductor layer are located. Subsequently, the second conductor layer having connecting areas is produced from the copper foil by etching, the connecting areas
30 being constructed as lands which surround the holes in the adhesive coating. The connecting of the lands with the contact areas takes place by the application of a conductive material, such as silver conductive paste or solder. In this method, the contact areas of the first conductor layer are separated from the lands of the second

conductor layer only by the thickness of the adhesive coating. Nevertheless, connection of the contact areas to the lands by automatic soldering, for example in a wave soldering bath, is not sufficiently reliable. DE-A1-2,716,545 also discloses a similar method.

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The object of the present invention is thus to improve a method in accordance with the precharacterising part of Claim 1 and a printed circuit board having at least two layers in accordance with the precharacterising part of Claim 7 to the effect
10 that the electrically conductive connections between the contact areas of the first conductor layer and the corresponding connecting areas of the second conductor layer can be established simply and reliably.

15 The invention achieves this object by means of a method of the generic type having the characterising features of Claim 1 and by a printed circuit board having at least two layers, in accordance with Claim 7.

First of all, an adhesive-coated conductive foil is laminated onto a support plate which is provided with a first conductor layer on at least one side, under the
20 influence of a high pressure of 50 to 150 bar especially from 80 to 120 bar, and at a temperature of at least 80°C. The pressing process preferably takes place in multiple-opening platen presses, in which case the laminate should be at a temperature of over 140°C for at least 5 minutes. In these pressing conditions, the material of the substrate plate softens so that the contact areas of the first conductor layer are curved so as to at
25 least partially, that is to say in a region of their surface, extend through the holes of the adhesive-coated conductive foil in the direction of the surface of the conductive foil. This curving of the contact areas of the first conductor layer takes place only at the points where the perforated conductive foil has holes, since the opposing pressure is absent, or is at least less, at these points during pressing.

30 The support plate which is provided with the first conductor layer can be produced from a copper-coated laminate (base material) in a manner which is known per se, for example by etching (subtractive method). However, other methods which are known from the prior art, such as the additive technique or the like, can also be used.

A laminate consisting of paper layers impregnated with resin is preferably used as the support plate, especially phenol-resin-paper laminated (FR-2) such as those marketed under the trademark Trolitax^R DN 8034 by Hüls Troisdorf AG. When the perforated conductive foil, which is provided with the adhesive, is being laminated on
5 under pressure, the resin should soften at least to such an extent that the desired curving of the, for example, copper material of the contact areas of the first conductor layer through the holes in the laminated-on conductive foil is possible in the direction of the surface of the conductive foil, or connecting areas, of the second conductor layer.

According to a preferred embodiment of the invention, the perforated
10 conductive foil having an adhesive coating is laminated directly, that is to say without an additional insulation coating, onto the support plate having the first conductor layer. In this case, the adhesive forms the only insulation (insulation coating) between the first and the second conductor layers.

According to a preferred embodiment of the invention, an acrylate
15 adhesive which can be softened by heat is used as the adhesive. The adhesive coating preferably has a thickness of 20 to 150 μm , especially from 35 to 60 μm . Surprisingly, it has been found that the insulation resistance between the first and the second conductor layer is completely adequate, even at the conductor crossing points, despite the extremely small thickness of the adhesive coating. The adhesive preferably has a
20 glass transition temperature of 50 - 70°C.

The conductive foil having an adhesive coating is provided with a hole, for example by punching, at the points where through-connecting, that is to say a conductive connection, is subsequently intended to take place between the contact areas of the conductors of the first layer and a connecting area of the conductors of the
25 second layer. The holes are preferably smaller than the corresponding contact areas of the first conductor layer, the holes - seen in projection - being in each case located completely inside the corresponding contact areas after the coating material has been laminated on.

After punching of the adhesive-coated conductive foil, said foil is fixed,
30 for example by means of a number of adhesive spots in the edge region, on the support plate which is provided with the first conductor layer. Subsequently, the perforated conductive foil is laminated with the support plate. The lamination of the perforated coating material with the support plate takes place preferably at a temperature above the

glass transition temperature T_G of the resin of the support plate, especially at a temperature of 140 to 180°C. The curving of the contact areas of the first conductor layer, which is achieved in this way, into the holes of the laminated-on, adhesive-coated, conductive foil has a decisely favourable effect on the subsequent electrically

5 conductive connection of the contact areas of the first conductor layer to the connecting areas of the second conductor layer, so that this connection can be formed especially by automatic soldering, for example in a wave-soldering bath, with high reliability. After the pressing operation, the distance between the surface of the contact areas (at their highest elevation) and the surface of the conductive foil is less than the thickness of the

10 conductive foil, preferably less than half the thickness of the conductive foil, and, in particular, less than 10 μm .

After lamination, the upper conductor layer is etched out of the conductive foil, for example in a manner known per se, so that the upper conductor pattern having the connecting areas is all that is left of the conductive foil the

15 connecting areas of the upper conductor layer are located at the points where the conductive foil has the holes and, at least touch and preferably completely enclose the holes of the laminated-on coating material and thus in each case form a land. The contact areas of the first conductor layer, located underneath, are visible through holes in the lands and the holes in the adhesive coating.

20 After etching, the multilayer printed circuit board is preferably provided in a manner known in the art with a solder resist, is drilled or punched, loaded, and subsequently automatically soldered. In this case, the solder resist is applied onto the second conductor layer such that in each case an area of the connecting areas of the second conductor layer remains free of solder resist and therefore can be wetted with

25 solder, this area free of solder resist is for example in the shape of a land which encloses the part of the contact area of the first conductor layer which is visible through the hole in the adhesive coating. This results in particularly reliable connection of the contact areas to the connecting areas, since the liquid solder is distributed uniformly on both areas (contact areas and connecting areas).

30 During soldering, the contact areas of the first conductor layer are electrically conductively connected to the corresponding connection areas of the second conductor layer at those points where the laminated-on, adhesive-coated, conductive foil had the holes. I required, the electrically conductive connection of the contact areas of

the first conductor layer to the corresponding connecting areas of the second conductor layer can also take place by the application and curing of an electrically conductive paste, for example a silver paste. However, a solder connection is more cost-effective and is this preferred.

- 5 During lamination of the perforated conductive foil having an adhesive coating to the support plate, it cannot be completely excluded that a small quantity of the adhesive penetrates into the holes in the conductive foil, and hence partially covers the contact areas of the first conductor layer. According to a preferred embodiment of the invention it is proposed that holes be provided through the support plate inside the
- 10 connecting areas or lands of the upper conductor layer. These holes, for example having a diameter of 0.7 mm, thus penetrate the connecting areas or lands of the upper (second) conductor layer, the contact areas of the first conductor layer and the support plate completely. During soldering in a wave-soldering bath, the adhesive residue which at least partially vaporises as a result of the high temperature of the solder can be
- 15 dissipated through these vent holes to the opposite printed circuit board surface. In this way, the reliability of the solder connection can be further increased.

- The method according to the invention makes it possible to produce printed circuit boards (PCBs) having at least two layers in a surprisingly simple and cost-effective manner, such PCBs having a first conductor layer and a second conductor
- 20 layer which are separated by an adhesive coating, the first conductor layer having contact areas (pads) and the second conductor layer having connecting areas (lands) corresponding thereto, and it being possible to electrically connect the contact areas to the corresponding connecting areas. Since the adhesive coating has holes at the points where the contact areas can be electrically conductively connected to the corresponding
- 25 connecting areas, through which holes the contact areas of the first conductor layer are curved at least partially in the direction of the surface or the connecting areas of the second conductor layer, and since the surfaces of the contact areas are in each case at a distance from the surface of the connecting areas of the second conductor layer which is less than the thickness of the connecting areas, electrically conductive connections
- 30 having particularly high reliability are achieved even by means of automatic soldering.

It is particularly advantageous if the holes in the insulation coating are smaller than the corresponding contact areas of the first conductor layer and if the surfaces of the holes - seen in projection - are located in each case completely inside the

corresponding contact areas.

Whenever this description refers to a first and a second conductor layer, this is to be understood to mean that it is also possible to apply further conductor layers in a corresponding manner. Furthermore, it is possible to start from a support plate
5 which is copper clad on both sides in order to obtain a PCB having a total of three layers by means of single-sided coating using a conductive foil, or a four-layer printed circuit board, as a result of applying in each case one conductive foil on both sides.

10 The invention will be explained in more detail using an exemplary embodiment and the drawing, in which:

Fig. 1 shows a support plate having the first conductor layer, in section,

Fig. 2 shows a plan view of the support plate according to Fig. 1,

15 Fig. 3 shows the perforated conductive foil having the adhesive coating, in section,

Fig. 4 shows the support plate having the perforated conductive foil fixed thereon, in section,

Fig. 5 shows a plan view of the support plate according to Fig. 4,

Fig. 6 shows a section through the printed circuit board after lamination,

20 Fig. 7 shows a section through the printed circuit board after etching of the upper conductive foil,

Fig. 8 shows a section through the printed circuit board after application of the solder resist,

25 Fig. 9 shows a section through the loaded and soldered two-layer printed circuit board,
the figs. no being shown to scale.

The exemplary embodiment of the invention represented in the following
30 text is based on a commercially-available, single-sided, copper-clad base material having a 35 μm copper coating. This base material (laminate) can be supplied by Hüls Troisdorf AG under the designation Trolitax^R DN 8034. The laminate consists of a support plate 2 based on phenol-resin paper, an adhesive coating 3 and a copper foil 4.

A printed circuit board 8 having a (first) conductor layer 7 with conductor tracks 5 and contact areas (pads) 6 is produced in a manner known per se by etching from the laminate (Fig. 1).

Fig. 2 shows that the contact areas 6 have an approximately circular or oval shape. The precise shape of these contact areas 6 is not critical, since only the shape of the holes 12 in the adhesive-coated, perforated copper foil 9 governs the subsequent shape of the contact areas 6 which can be soldered.

In order to produce the perforated conductive foil 9 having an adhesive coating, a copper foil 1 having a thickness of 35 μm is provided with an adhesive coating 10 having a thickness of 40 μm . A commercially-available acrylate adhesive is used as the adhesive, which is (initially) cured into the B-stage, a glass (transition) temperature T_G of 60°C being set. It is important that the adhesive forming the adhesive coating 10 cross-links only to the extent that an adequate adhesive capability remains in order to achieve an adequate adhesion of the layers in the subsequent laminate 1. On the other hand, the adhesive should have a viscosity which is sufficiently high to largely suppress the adhesive penetrating into the holes 12 in the copper foil 11 during compression.

The copper foil 11 (conductive foil) which is provided with the adhesive coating 10 is subsequently perforated using a punching tool, so that a hole 12 is punched through the adhesive-coated foil 9 at every point where a contact 17 is provided between the contact areas 6 of the first conductor layer 7 and the corresponding connecting areas 16 of the second conductor layer 19. The holes 12 have a circular shape, as can be seen especially in Fig. 5.

The punched foil 9 (Fig. 3) is subsequently laid in a precisely fitting manner on the etched printed circuit board 8, is fixed by means of a number of adhesive spots and is compressed in a multiple-opening platen press at a pressure of 100 bar. In this case, the press is heated to a temperature of approximately 160°C. The laminate 13, which is formed from the etched printed circuit board 8 and the punched foil 9, is heated within approximately 20 minutes to 160°C during compression, by heat conduction. It is subsequently cooled within a further 30 minutes, while maintaining the pressure.

During the pressing process, the adhesive coating 10 and the support plate 2 of the etched printed circuit board 8 soften. Since the pressure is absent or is at least

less at the points where the foil 9 has the holes 12, the regions of the contact areas 6 of the first conductor layer 7 lying under the holes 12 are curved upwards through the holes 12 in the direction of the surface of the second conductor layer 19. This effect can be seen clearly in Fig. 6. As a result of this partial curving upwards of the contact areas 5 6 through the holes 12, penetration of the adhesive of the adhesive coating 10 into the holes 12 is largely suppressed. At the same time, the (curved) surfaces of the contact areas 6 and the surfaces of the adjacent connecting area 16 approach one another the interval between them being less than the thickness of the connecting areas 16, so that subsequent connecting by soldering is simplified. During compression, the adhesive of 10 the adhesive coating 10 is distributed in the intermediate space between the conductor tracks 5 and the contact areas 6 of the first conductor layer 7, an insulation coating 23 remaining between the conductor tracks 5 and copper foil 11. In the case of a conductor thickness of the first conductor layer 7 of 35 μm , a thickness of the adhesive coating 10 of 40 μm , selected in this exemplary embodiment of the invention, a remaining 15 insulation thickness of approximately 15 to 20 μm is guaranteed, which leads to adequate insulation.

The conductor tracks 5 of the first conductor layer 7 can alternatively be pressed completely or partially into the surface of the support plate 2 during compression, depending on the hardness and viscosity of the adhesive of the adhesive 20 coating 10 used and on the hardness and viscosity of the resin of the support plate 2, so that the thickness of the remaining insulation coating 23 corresponds approximately to the original thickness of the adhesive coating 10 (not shown in the figures).

After lamination, the upper copper foil (conductive foil 11) is etched away in a manner known per se, with the exception of the second conductor layer 19, so that 25 only the conductor tracks 15 and the connecting areas 16 of the copper foil (conductive foil 11) of the copper foil (Fig. 7).

The etched laminate 14 is subsequently provided with a solder resist 20, in a conventional manner. In this case, the upper connecting areas 16 are bounded in such a manner that they assume the shape of lands which surround the regions of the 30 contact areas 6 which are visible through the holes 12.

After application of the solder resist 20, the at least two-layer printed circuit board 1 is drilled in a manner known per se (holes 22), loaded (Fig. 8, Fig. 9), and subsequently automatically soldered in the wave-soldering bath. In this process, on

the one hand, the leads 21 of component parts are connected to the upper conductor tracks 15 of the second conductor layer 19 by means of the solder 18. The leads 21 can also be connected to corresponding lands of the first conductor layer (not shown), if the adhesive coating 10 is either removed in advance from the appropriate points or is
5 absent as a result of a larger hole in the foil 9.

Fig. 9 shows the contact 17 between the connecting area 16 and the contact area 6, located underneath, by means of the solder 18. If necessary, an improvement in the reliability of the solder connection can be achieved by means of a vent hole 22 which passes through the connecting area 16, the contact area 6 and the
10 support plate 2.

For the reliability of the solder contact, it is essential that the surface of the contact area 6 has as little adhesive residue as possible and that the surface of the contact area 6 has been pressed as far as possible through the holes 12 in the adhesive-coated, perforated copper foil 9, and is thus located at approximately the same surface
15 level as the connecting areas 16. By selecting an appropriate part of the surface of the contact area 6 which can be wetted with the solder 18 and of the connecting area 16 it is ensured that a uniform distribution of the solder 18 is achieved by means of surface-tension effects.

The rear side of the support plate 2 can also be provided with one or two
20 additional conductor layers in the same manner in which the upper conductor layer 19 is applied and contacted.

Legend

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| 1 | Printed circuit board |
| 2 | Support plate |
| 3 | Adhesive (for first conductor layer) |
| 5 4 | Copper foil (for first conductor layer) |
| 5 | Conductor track (for first conductor layer) |
| 6 | Contact area (for first conductor layer), pad |
| 7 | First conductor layer |
| 8 | Etched printed circuit board (single-sided) |
| 10 9 | Foil (adhesive-coated, perforated copper foil) |
| 10 | Adhesive coating (for second conductor layer) |
| 11 | Conductive foil (for second conductor layer) |
| 12 | Hole |
| 13 | Laminate before etching |
| 15 14 | Laminate after etching |
| 15 | Upper conductor track |
| 16 | Connecting area (second conductor layer), land |
| 17 | Electrically conductive connection, contact |
| 18 | Solder |
| 20 19 | Second conductor layer |
| 20 | Solder resist |
| 21 | Lead of a component part |
| 22 | Hole |
| 23 | Insulation coating |

**CLAIMS:**

1. Method for producing a printed circuit board (1) having at least two layers and having a support plate (2), a first conductor layer (7) with contact areas (pads 6) and a second conductor layer (19) with connecting areas (lands 16), in which
- a conductive foil (11), provided with an adhesive coating (10), is laminated onto
5 the support plate (2) having the first conductor layer (7) and the contact areas (pads 6), at a temperature of more than 80°C,
 - the adhesive coating (10) and the conductive foil (11) having holes (12) which correspond to the contact areas (pads 6) of the first conductor layer (7),
 - the second conductor layer (19) having the connecting areas (lands 16) is
10 subsequently produced from the conductive foil (11),
 - the connecting areas (lands 16) of the second conductor layer (19) adjoining the holes (12) in the adhesive coating (10),
 - after which the contact areas (pads 6) of the first conductor layer (7) can be
15 electrically conductively connected to the corresponding connecting areas (lands 16) of the second conductor layer (19) through the hole (12) of the adhesive coating (10), by means of soldering or by the application of a conductive paste, characterised in that
 - the perforated conductive foil (11), provided with the adhesive coating (10), is
20 laminated at a pressure of 50 to 150 bar onto the support plate (2) having the first conductor layer (7),
 - the contact areas (6) of the first conductor layer (7) being curved so as to at least partially extend through the holes (12) of the adhesive coating (10) and of the conductive foil (11) in the direction of the surface of the conductive foil (11),
 - 25 - so that - after subsequently producing the second conductor layer (19) with the connecting areas (16) from the conductive foil (11) - the surfaces of the contact areas (6) are in each case at a distance from the surface of the connecting areas (16) of the second conductor layer (19) which is less than the thickness of the



connecting areas (16).

2. Method as claimed in Claim 1, characterized in that the adhesive coating (10) consists of an acrylate adhesive which can be softened by heat and which has a glass transition temperature T_G of 50 - 70°C and a thickness of 20 to 150 μm ,
5 preferably 35 to 60 μm .
3. Method as claimed in Claim 1 or 2, characterised in that the contact areas of the first conductor layer (7) are connected to the corresponding connecting areas of the second conductor layer (19) by automatic soldering in a wave-soldering bath.
- 10 4. Method as claimed in Claim 3, characterised in that, before soldering, holes (22) are drilled or punched through the connecting areas and the contact areas (6) of the two conductor layers (7, 19), which holes (22) pass through the support plate (2).
5. Method as claimed in any one of Claims 1 to 4, characterised in that a
15 laminate consisting of paper layers impregnated with resin is used as the support plate (2).
6. Method according to Claim 5, characterised in that the perforated conductive foil (11), provided with the adhesive coating (10), is laminated to the support plate (2) having the first conductor layer (7), under the influence of pressure of
20 80 to 120 bar, at a temperature above 140°C.
7. Printed circuit board (1) having at least two layers, comprising a first conductor layer (7) and a second conductor layer (19) which is separated therefrom by an adhesive coating (10),
 - the first conductor layer (7) having contact areas (6) and the second conductor
25 layer having connecting areas (16) corresponding thereto, and
 - the contact areas (6) and the corresponding connecting areas (16) being interconnectable in an electrically conductive manner,
 - the adhesive coating (10) having holes (12) at the points where the contact areas (6) can be electrically conductively connected to the corresponding connecting
30 areas (16),characterised in that
 - the contact areas (6) of the first conductor layer (7) are curved so as to at least partially extend through the holes (12) in the adhesive coating (10) in the



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direction of the surface of the connecting areas (16) of the second conductor layer (19),

- and in that the surfaces of the contact areas (6) are in each case at a distance from the surface of the connecting areas (16) of the second conductor layer (19), which is less than the thickness of the connecting areas (16).

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