

PRINTED CIRCUIT BOARD AND METHOD OF CONNECTING ELECTRONIC PARTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a technique of mounting electronic parts at a high density on a printed circuit board and, more particularly, to a structure of a printed circuit board and a method of mounting integrated circuit (IC) packages, a tape automated bonding (TAB) type of tape carrier package (TCP) and the like on the printing circuit board in a surface mounting manner.

2. Description of the Related Art

Conventionally, soldering has widely been used to mount electronic parts on printed circuit boards. In the field of mounting by soldering, with the advancement of miniaturization and combination of parts based on the development of large-scale semiconductor IC integration techniques, the method of mounting package type and bare chip type IC parts in a surface mounting manner has come into major use replacing the early-developed method of mounting parts with leads such as single-in-line packages (SIP) and dual-in-line packages (DIP) by inserting the leads in a circuit board, because it is advantageous in terms of assembly automatization and electronic characteristics. In particular, TCPs have a large chip area and are suitable for multi-pin arrangement. TCPs also have the advantage of capability of being mounted at a high density because the lead pitch can be reduced.

Surface mount devices (SMD) are usually connected to circuit boards by reflow soldering. Reflow soldering is performed in such a manner that an SMD is set on solder layers previously formed on electrode pads (lands) on a circuit board, and the solder layers are melted to fix the device by being heated in a reflow furnace. On the other hand, TCPs are ordinarily connected in such a manner that outer leads of a TCP are pressed, with a bonding tool, against solder layers previously formed on lands on a circuit board, and the members to be connected to each other are heated by a local heating manner while being pressed against each other. This is because the outer leads of TCPs are very soft and deformable. Such solder layers are formed at a time, for example, by printing cream solder on the circuit board where no parts are mounted. To improve the wettability of

solder, flux is ordinarily used. Recently, from the viewpoint of earth environmental protection, use of water-soluble or cleaning-free type flux for soldering has been increased. As connection means other than soldering, alloying by thermocompression bonding, a method of using an anisotropic conductive sheet or a photo-curable insulating resin and other methods are used.

According to the above-described conventional mounting methods, if an SMD and a TCP are mixedly mounted on one circuit board, a process step for connecting the TCP is ordinarily performed after a reflow step for connecting the SMD. In such a case, as shown in Fig. 12, solder layers 31 on lands 35 to which a TCP are to be connected are melted by the preceding reflow step so as to round into a semispherical shape by the effect of its surface tension. It is possible that outer leads 32 of the TCP placed on the solder layers 31 slip down leftward or rightward as viewed in Fig. 12 when pressed by a bonding tool 33, so that they are not accurately bonded to the corresponding lands 35, resulting in occurrence of connection failure, i.e., short-circuit or the like, even if the pressing direction is perpendicular to circuit board 34. Therefore, there is a problem of a reduction in yield and, hence, an increase in manufacturing cost. Positioning of outer leads of a TCP on a circuit board becomes more difficult and a misalignment of the leads can occur more easily if the pitch between the outer leads becomes smaller with the increase in the integration density or the density of ICs. If a special positioning means or fixing means is used to cope with this problem, then a troublesome operation is required to use such means; the amount of labor and time taken for positioning are increased and the manufacturing cost is also increased.

The development of SMDs having a larger number of pins and a smaller pin pitch have also been promoted. Accordingly, in the case of mounting a multiplicity of SMDs on a circuit board at a time in a surface mounting manner, it is difficult to accurately position the leads of the devices, and there is a substantially high probability of occurrence of solder bridging and misalignment. Further, if SMDs and TCPs are mixedly mounted, the total number of mounting steps is large and the time required for mounting is considerably long, because they are mounted by separate connecting steps.

In view of the above-described problems of the conventional art, an object of the present invention is to provide a printed circuit board which is designed to cope with the problem of a reduction in lead pitch and an increase in density of ICs, and on which electronic parts including an SMD and a TCP be soldered can be positioned always accurately and can be mounted in a surface mounting manner so as to be maintained in a

good connected condition.

Another object of the present invention is to provide a method which ensures that electronic parts including an SMD and a TCP to be mounted on a printed circuit board can be positioned always accurately and can be soldered easily at a low cost to be maintained in a good connected condition. Specifically, the present invention aims to provide a method suitable for mounting a TCP on a printed circuit board without largely changing the conventional mounting process, without largely increasing the number of steps of the conventional mounting process and without using any special position and fixing means.

Still another object of the present invention is to provide a method for mounting a multiplicity of electronic parts at a time in a surface mounting manner so that the electronic parts are maintained in a good connected condition by soldering.

Leads of electronic parts are soldered to lands on a printed circuit board, for example, in a manner described below. First, as shown in Fig. 13A, a dispenser 36 is used to supply flux 37 to a region including a land 34 on the printed circuit board. If the flux is a water-soluble or cleaning-free type flux as mentioned above, it spreads to such an extent as to partially cover the surface of a resist layer surrounding the land 34, since the viscosity of the flux is low. Therefore, there is a possibility of failure to sufficiently immerse a connected end portion of a lead 32 placed on a solder layer 31. If the connected end portion is pressed and heated by a bonding tool 39 in a state of being not sufficiently immersed in the flux, the connected end portion cannot be sufficiently wetted with the solder. In such a situation, the probability of occurrence of connection failure is high and the yield is reduced. In particular, in the case of a part such as a TCP having a multiplicity of leads arranged with a very small pitch, a troublesome correction operation and a long time are required to correct even a connection failure of only one lead.

In view of this problem, yet another object of the present invention is to provide a printed circuit board arranged to enable flux to be supplied by a comparatively simple means so that leads of electronic parts are sufficiently immersed in the flux when leads of electronic parts are soldered by local heating using a bonding tool, whereby the wettability of the solder is improved to enable each lead of the electronic parts to be connected in a good condition.

Still another object of the present invention is to provide an electronic parts connection method which makes it possible to sufficiently supply flux in a comparatively simple manner and to suitably connect leads of electronic parts to lands on a circuit board.

When leads and lands are pressed against each other with a bonding tool as described above, it is important to maintain a certain parallelism between the bottom surface of the bonding tool and the surface of the printing circuit board. As shown in Fig. 14, if a bottom surface 40 of a bonding tool 39 presses leads 32 of electronic parts in a state of being inclined with respect to a circuit board 34, there is a possibility of the leads slipping down solder layers 31 of corresponding lands 35 to cause connection failure or short-circuit in wiring. If the lead pitch is very small as in the case of a TCP, a misalignment can occur easily between the leads and lands even if the inclination is small. For example, in a case where a through hole is formed in the vicinity of a land or a material is attached to an applied layer of a resist 38 on a wiring pattern 41 by silk screen printing or the like so as to form a character 42 or the like, the bottom surface 40 of the bonding tool abuts one-sidedly against the protrusion of the character 42 or the like so that the desired parallelism is lost if the height of the character or the like is larger than that of the lands only by 20 mm. If as shown in Fig. 14 a multiplicity of leads and corresponding lands are arranged with a small pitch, the bonding tool may be replaced by a different one having a bottom surface size and a bottom surface configuration conforming to the lead arrangement to avoid the above-described problem of parallelism. In such a case, however, a universality of the bonding tool is lost; a need for changing and positioning a bonding tool for each process step arises as well as a need for preparing various types of bonding tools. A large amount of labor and a long time are thereby required, resulting in a considerable increase in manufacturing cost.

Therefore, a further object of the present invention is to provide a printed circuit board arranged so that while a certain universality of a bonding tool is maintained, the bonding tool is set with a suitable parallelism to limit misalignments of leads of electronic parts on lands to which the leads are to be connected, whereby the leads can always be connected in a good condition.

On a printed circuit board, a plurality of marks for accurately positioning electronic parts which are to be connected to the printed circuit board are provided. Such positioning marks are sometimes formed by portions of wiring patterns, but are ordinarily provided on a circuit board as marks independent of wiring patterns. Japanese Patent Laid-Open Publication No. 60-161693 discloses a printed circuit board arranged with such recognition marks provided at arbitrary positions on the board, particularly in the vicinity of mount portions of electronic parts so that the electronic parts can be accurately positioned. However, if such positioning marks are provided only at arbitrary positions,

a need for increasing the area of the printed circuit board arises and it is difficult to increase the density of mounted parts and the density of wiring. Moreover, the circuit wiring becomes complicated and the freedom of circuit design is reduced, so that the circuit design cannot be sufficiently adapted for miniaturization of the circuit board and semiconductor devices. It is also necessary for the positioning marks to be formed so as to be clearly recognizable, because the positioning marks are optically detected by a sensor.

Accordingly, still a further object of the present invention is to provide a printed circuit board arranged so that positioning marks more clearly recognizable are provided by effectively utilizing the area of the circuit board to improve the degree of freedom of circuit design, and which can be suitably reduced in size while the density of parts mounted thereon is increased.

SUMMARY OF THE INVENTION

To achieve the above-described objects, according to one aspect of the present invention, there is provided a printed circuit board comprising lands to which leads of at least one electronic part to be mounted are connected, and a solder layer formed on each of the lands, wherein the upper surface of the solder layer is flattened.

In the above-described printed circuit board, the solder layers having the flat upper surface and the lands may be covered with a removable heat resistant resin material before the leads of the electronic part are connected thereto.

According to another aspect of the present invention, there is provided a method of mounting at least one electronic part on a printed circuit board having lands corresponding to leads of the electronic part, and a solder layer formed on each land, the method comprising the steps of flattening the upper surface of the solder layer, placing leads of the electronic part on the solder layers, and connecting the lands and the leads by soldering.

In the above-described electronic part connection method, the upper surface of the solder layer may be flattened by pressing. Pressing may be performed by using at least one roller. Further, the length of the roller may be longer than the length of one side of the printed circuit board, and the entire surface of the printed circuit board may be pressed at a time. Alternatively, the printed circuit board may be partially pressed by using the roller.

In the above-described method, pressing may alternatively be performed by using a bonding tool. Further, a plurality of the printed circuit boards may be stacked one on

another and may be pressed at a time by using the bonding tool.

In the above-described method, pressing may alternatively be performed by pinching the printed circuit board between metallic plates. Further, a plurality of printed circuit boards may be stacked one on another and may be pressed by using the metallic plates. The entire surface of the printed circuit board may be pressed at a time by using the metallic plates. Alternatively, the printed circuit board may be partially pressed by using the metallic plates.

In the above-described method, the upper surface of the solder layer may be heated simultaneously with the pressing.

In the above-described method, the leads placed on the solder layers and the lands may be soldered by being heated. Leads of a plurality of electronic parts may be placed on the corresponding lands and may be soldered to the same at a time. The plurality of electronic parts may include a tape carrier package type part. The leads and the lands may be soldered by being pressed simultaneously with the heating.

In the above-described method, the electronic part may be a tape carrier package type part and may be connected after a reflow step.

Further, the above-described method may be such that, after the upper surfaces of the solder layers have been flattened, the solder layers and the lands are temporarily covered with a heat resistant resin material, the resin material is thereafter removed, and the leads of the electronic part are then placed on the solder layers.

According to yet another aspect of the present invention, there is provided a printed circuit board comprising lands to which leads of at least one electronic part to be mounted are connected, a solder layer formed on each of the lands, and at least one frame formed so as to surround the lands and so as to be higher than the solder layer.

In this printed circuit board, the frame may be formed by silk screen printing.

According to still another aspect of the present invention, there is provided a method of mounting at least one electronic part on the above-described printed circuit board, comprising the steps of supplying flux to a region surrounded by the frame, placing the leads of the electronic part on the solder layers so that the leads are immersed at least partially in the flux, and pressing and heating the leads, the solder layers and the lands to connect the lands and the leads.

According to a further aspect of the present invention, there is provided a printed circuit board comprising lands to which leads of at least one electronic part to be mounted are connected by being pressed with a bonding tool, and a region lower in height than the

lands and provided in an area corresponding to a bottom surface of the bonding tool.

In this printed circuit board, the electronic part may have leads arranged along its four sides, and the region may be provided in a rectangular frame-like area which corresponds to the leads and in which the lands are located.

According to still a further aspect of the present invention, there is provided a printed circuit board comprising a substrate on which at least one electronic part chip is mounted, and marks for positioning the electronic part chip when the chip is mounted, wherein the positioning marks are provided inside a region of the substrate to which the electronic part chip is directly fixed.

According to still a further aspect of the present invention, there is provided a printed circuit board comprising a substrate on which at least one electronic part chip is mounted, and marks for positioning the electronic part chip when the chip is mounted, wherein the substrate has a multilayer structure having an inner layer processed by a blackening treatment at positions corresponding to the positioning marks.

In the printed circuit board in the first aspect of the present invention, when the leads of the electronic part to be mounted are placed on the solder layers, the leads are preventing from slipping down, so that the leads and the lands can be stably maintained in a good connected condition.

In addition, when a heat treatment such as a reflow step is previously performed to connected other electronic parts, the desired flatness of the upper surfaces of the solder layers used in a subsequent step can be maintained.

In the electronic part connection method in the second aspect of the present invention, when the leads of the electronic part are placed on the upper surfaces of the solder layers in accordance with the conventional mounting process, there is substantially no possibility of the leads slipping down, and the leads can be soldered in a state of being correctly positioned. It is therefore possible to suitably connect the leads and lands reliably in a very simple manner if only a few process steps are added to flatten the solder layers.

In the electronic part connection method, the conventional mounting process can be utilized without being changed except that a pressing step is added before the step of placing the leads of the electronic part, whereby the solder layers can be easily flattened. This pressing can be performed in a simple manner without largely charging the conventional process, and the pressing step may be a step of rolling a roller on the upper surfaces of the solder layers, a step utilizing a bonding tool or a step of pinching the

printed circuit board between metallic plates. Also a plurality of printed circuit boards may be stacked and pressed to flatten the solder layers thereof at a time. Further, the solder layers may be partially melted by heating to flattened more easily.

In the electronic part connection method in the second aspect of the invention, the solder layers on which the leads of the electronic part are placed are melted by heating to perform reflow soldering. A plurality of electronic parts can also be soldered at a time by one step to be maintained in a good connected condition. Also, an SMD and a TCP can be simultaneously mounted in a surface mounting manner by one reflow step. It is also possible to connect the leads of the electronic part by local heating without any misalignment between the leads and the lands.

In a case where a TCP is connected after the reflow step, the TCP having a multiplicity of pins and a small lead pitch can be suitably connected to the printed circuit board without being affected by heating of the reflow step.

Even if heat is applied to the printed circuit board by the reflow step to connected other electronic parts after flattening the upper surfaces of the solder layers, the desired flatness of the upper surfaces of the solder layers can be maintained before a resin material covering the circuit board is removed.

In the printed circuit board in the third aspect of the present invention, even if a water-soluble or cleaning-free type flux having a comparatively low viscosity is used, the flow of flux is limited by the frame so that a sufficiently large amount of flux can be supplied to a region including the lands, thereby enabling the leads to be sufficiently immersed in the flux.

On this printed circuit board, the frame can be formed simultaneously with various characters or symbols provided on the surface of the printed circuit board by silk screen printing.

In the electronic part connection method in the fourth aspect of the present invention, a sufficiently large amount of flux can be supplied to connected portions of the lands and the leads by the effect of the frame, so that the solder can suitably wet the leads to improve the soldering effect.

In the printed circuit board in the fifth aspect of the present invention, when the lands and the leads placed on the lands are pressed by using a bonding tool, the bottom surface of the bonding tool contacts no surface portion of the circuit board other than the leads, so that the desired parallelism of the bottom surface with respect to the circuit board surface can be maintained.

In this printed circuit board, even in a case where all the leads provided along the four sides of the electronic part are connected to the corresponding lands by performing pressing one time with a bonding tool, the desired parallelism of the bottom surface of the bonding tool can be maintained.

In the printed circuit board in the sixth aspect of the present invention, an area inside the area on the substrate where the electronic part chip is directly connected is utilized for releasing heat from the chip and/or ground line connection and no signal conductors are provided in this area. Accordingly, positioning marks can be provided in this area without any hindrance to circuit design on the substrate. Also, the marks can be formed independently of wiring patterns on the substrate to have improved recognizability.

In the printed circuit board according to the seventh aspect of the present invention, positioning marks can be recognized more clearly by the effect of contrast with an inner layer processed by a blackening treatment.

These and other features and advantages of the present invention will become apparent from the following detailed description of the preferred embodiments of the invention with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic perspective view of a printed circuit board unit to which the present invention is applied;

Fig. 2 is a schematic perspective view of a printed circuit board for use in the printed circuit board unit shown in Fig. 1;

Figs. 3A and 3B are cross-sectional views of a method of flattening solder layers formed on lands on the printed circuit board;

Fig. 4 is a cross-sectional view of another method of flattening solder layers;

Fig. 5 is a cross-sectional view of still another method of flattening solder layers;

Fig. 6 is a plan view of lands and frames formed on the printed circuit board of the present invention;

Fig. 7 is a cross-sectional view taken along the line VIII - VIII of Fig. 6;

Figs. 8A and 8B are enlarged cross-sectional views of process steps for soldering outer leads to the lands shown in Fig. 7 by using flux;

Fig. 9 is a plan view showing positioning marks formed on the printed circuit board of the present invention;

Fig. 10 is a cross-sectional view taken along the line X - X of Fig. 9, showing a

state of outer leads and lands connected by using a bonding tool;

Fig. 11 is a plan view of another example of the arrangement shown in Fig. 10;

Fig. 12 is a cross-sectional view of a conventional printed circuit board when outer leads of a TCP and lands are connected to each other;

Figs. 13A and 13B are enlarged cross-sectional views of process steps for soldering the outer leads to the lands on the conventional printed circuit board by using flux; and

Fig. 14 is a cross-sectional view of the conventional printed circuit board when the outer leads and the lands are connected to each other by using a bonding tool.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 schematically illustrates an embodiment of a printed circuit board unit 1 to which the present invention is applied. The printed circuit board unit 1 is used as a card-type computer. The printed circuit board unit 1 is constructed in such a manner that a TCP formed of a CPU for the computer, a sub board 4, on which electronic parts including, for example, an electrically programmable read only memory (EPROM) are mounted, and other electronic parts (not shown) are mounted on a printed circuit board 2 in accordance with the present invention. The printed circuit board unit 1 is a double-side mount type circuit board having a multilayer structure. A TCP, a sub board and other electronic parts similar to those mentioned above are also mounted on the reverse surface (not shown) of the printed circuit board unit 1. A connection terminal array 5 for connection to a memory board forming a main memory for the above-mentioned computer is formed in the vicinity of the TCP 3 along one of two major sides of the printed circuit board unit 1, while a connector 6 is provided along the other major sides of the printed circuit board unit 1 so as to extend through the entire length of the same.

Fig. 2 illustrates the printed circuit board 2 before the TCP 3, the sub board 4 and other electronic parts are mounted. Lands 8 to which outer leads 7 disposed with a small pitch on four sides of the TCP 3 are to be connected are formed on the surface of the printed circuit board 2 at positions corresponding to the outer leads 7. Also, a multiplicity of lands 10 to which terminals 9 provided on peripheral portions of the sub board 4 are to be connected are formed on the surface of the printed circuit board 2 at positions corresponding to the terminals 9. In this embodiment, the sub board 4 are connected by reflow soldering simultaneously with other surface-mounted parts (not shown). The TCP 3 is connected by a well-known local heating method of pressing and

heating only connected portions with a bonding tool, as described above, after the sub board 4 and other parts have been soldered by a reflow step and after the other electronic parts have been soldered by a flow step, i.e., at the end of a mounting process.

As shown in Fig. 3A, lands 8 are arranged on the printed circuit board 2 with a small pitch, and a solder layer 11 is formed on each land 8. Solder layer 11 is previously formed, for example, by melting a multiplicity of small solder grains bonded to each land surface along with other soldering connection portions on the printed circuit board 2 before the operation of mounting the parts is started. Therefore, solder layer 11 is solidified while being formed into a semispherical shape by its surface tension, as shown in Fig. 3A, before being melted by the above-mentioned reflow step for connecting the sub board 4 and other parts. According to the present invention, as shown in Fig. 3B, a roller 12 is rolled on the printed circuit board 2 and moved in a horizontal direction along the same to apply a certain load upon the upper surface of each round solder layer 11, thereby pressing the same into a flat shape.

While roller 12 is rolled on the fixed printed circuit board 2 in the above-described embodiment, pressing may be performed by moving a printed circuit board while fixing a roller at a predetermined position according to another embodiment of the present invention. In this case, only one roller is disposed on the upper side of the printed circuit board or the printed circuit board may be passed through the nip between a pair of parallel rollers to be pressed.

When the outer leads 7 of the TCP 3 are placed on the upper surface of the solder layers 11 thus flattened, they do not slip down as those on the conventional printed circuit board shown in Fig. 12, and can be stably soldered and suitably connected. The above-described operation of pressing the solder layers with at least one roller is performed one time or, if necessary, a certain number of times. The above-described pressing may be performed on the entire surface of the printed circuit board or only on a restricted area of the printed circuit board selected according to the sizes and shapes of the printed circuit board 2 and the roller 12, the dispositions of solder layers and mounted parts and convenience of operations. To press the entire surface of the printed circuit board at a time, it is necessary that the length of the roller 12 is longer than the length of one side of the printed circuit board. The solder layer 11 may be formed by printing a cream solder according to another embodiment of the present invention.

Fig. 4 shows another embodiment of the method of flattening the upper surfaces of solder layers 11. In this embodiment, a bonding tool 13 is used to connect the outer

leads 7 of the TCP 3 and the lands 8 of the printed circuit board 2, and the bottom surface of the bonding tool 13 is pressed against the upper surfaces of the solder layers 11 before the outer leads 7 are placed on the solder layers 11. In this manner, the upper surfaces of the solder layers 11 can easily be flattened. According to this method, there is no need to newly prepare a pressing means such as a roller as shown in Fig. 3, and the desired flattening effect can be achieved by adding only one process step utilizing the bonding tool 13. In still another embodiment of the flattening method of the present invention, the solder layers 11 are heated simultaneously with pressing using the bonding tool 13. The solder layers 11 are thereby melted so as to be easily flattened. The bonding tool is cooled after melting the solder layers 11, and is moved upward after the solder layers 11 has solidified. In a further embodiment of the flattening method of the present invention, a plurality of printed circuit boards are stacked one on another and are pressed with a bonding tool, thereby flattening solder layers of the plurality of printed circuit boards at one time.

In a still another embodiment of the present invention as shown in Fig. 5, before a heat treatment, e.g., a reflow step, i.e., a step of applying heat to solder layers 11, is performed on the printed circuit board 2, lands 8 and solder layers 11 are entirely covered with a heat resistant resin layer 14 which can be removed comparatively easily afterward. As the covering resin, an acrylic resin or UV curing type resin material may be used suitably. The cover resin layer 14 may be peeled off and removed from the surface of the printed circuit board after the heat treatment and before TCP 3 is connected.

It is convenient to previously flatten the upper surfaces of solder layers 11 before covering with the heat resistant resin layer 14. For example, solder layers 11 can be flattened by being pressed with a roller one time or, if necessary, a certain number of times through their entire surfaces when no parts are mounted on the printed circuit board 2, as in the case described above with reference to Figs. 3A and 3B. Also, only solder layers which need to be flattened may be selectively pressed by a roller. In such a case, solder layers which do not need to be flattened may be previously covered with the heat resistant resin. If a printed circuit board on which solder layers 11 are previously formed so as to have flat surfaces is used, a heat resistant resin film can be coated directly thereon.

Solder layers are also formed on the lands 10 for connection of the sub board 4 and the lands for connection to the above-mentioned other surface-mounted parts on the printed circuit board 2, as in the case of the lands 8 for connection of the TCP. These solder layers are formed at a time simultaneously with the solder layers 1 on the lands 8 by

the above-described method when no parts are mounted on the printed circuit board 2. In a further embodiment of the present invention, the upper surfaces of solder layers other than those on the lands 8 can also be flattened before the sub board 4 and the above-mentioned other surface-mounted parts.

Flattening is performed by rolling a roller such as that shown in Fig. 3B on the entire or a necessary part of the surface of the printed circuit board one time or, if necessary, a certain number of times, as described above with respect to the solder layers 1 on the lands 8. A pressing tool such as the bonding tool shown in Fig. 4 may also be used one time or more times on the entire or a necessary part of the surface of the printed circuit board to flatten the solder layers. In this embodiment, it is convenient to simultaneously flatten all the lands on the printed circuit board 2 including the lands 8 for the TCP 3 and the lands 10 for the sub board 4.

If the entire surface of the printed circuit board at a time, the printed circuit board is pinched between flat plates each having a size larger than that of the printed circuit board, and is pressed so that applied pressure is uniform through the entire surface of the printed circuit board. As the flat plates, metallic plates, e.g., iron plates having a such a strength as not to be deformed by a substantially large external force may be used. If the metallic plates have a size larger than that of the printed circuit board, the solder layers on the entire surface of the printed circuit board can be flattened at a time, as mentioned above. If flattening of only solder layers on a necessary portion suffices, the plates may have a size smaller than that of the printed circuit board. If it is difficult to press the entire surface of the printed circuit board at a time because of the existence of a protrusion or the like thereon, the above-mentioned flat plates may be formed into any desired shape, for example, by being partially cut out. According to the present invention it is possible to flatten all solder layers on a plurality of printed circuit boards by stacking the printed circuit boards and pressing the boards by using the above-mentioned flat plates. In each of these cases, pressing and heating may be performed simultaneously.

As described above, the upper surfaces of the lands other than lands 8 are flattened to enable the sub board 4 and the above-mentioned other surface-mounted parts to be easily positioned and mounted with accuracy so as to be connected always in a good condition. It is also possible to place TCP 3 place on the lands 8 simultaneously with these surface-mounted parts and to simultaneously solder TCP 3 and the other surface-mounted parts at a time by reflow soldering, whereby the parts can be suitably connected without occurrence of a lead misalignment, as in the case of using the bonding tool shown

in Fig. 4. For the reflow step, any of various well-known techniques, i.e., an overall heating method using infrared rays or hot air, local heating methods such as a laser method and an optical beam method, and the like can be used. Needless to say, in a case where TCP 3 cannot be mounted together with sub board 4 and other parts, for example, due to the problem of the heat resistance of the carrier tape, it can be separately connected in a step after the step of mounting the above-mentioned surface-mounted parts, as in the case of the embodiment described above with reference to Fig. 2.

Further, on the printed circuit board 2 of the present invention, as shown in Figs. 6 and 7, resin frames 15 and 16 are provided along the arrays of lands 8 corresponding to the arrays of outer leads 7 of TCP 3, approximately conforming to four sides of a square in this embodiment, so as to surround the arrays of lands 8 from the outside and inside of the same. Resin frames are also formed in a similar manner even if the arrays of lands 8 form a shape other than the above-mentioned square shape, for example, they form four sides of a rectangle in correspondence with the arrays of outer leads of TCP 3, or opposite or adjacent two of four sides of a square or rectangle. As shown well in Fig. 7, each of the resin frames 15 and 16 is formed on a resist layer 17 formed on the surface of the printed circuit board 2 so as to be sufficiently higher than the solder layer 11. The resin frames 15 and 16 are formed of the same printing material as characters, symbols or the like provided on the printed circuit board 2 by silk screen printing without increasing the number of process steps. Therefore, the resin frames 15 and 16 can be formed at a low cost without requiring a considerably large amount of labor or time.

To connect TCP 3, flux 19 is first supplied to a position above the lands 8 and the solder layers 11 by using a well-known dispenser 18, as shown in Fig. 8A. Even if the viscosity of flux 19 is low, the flow of flux 19 is stopped by the resin frames 15 and 16 so that flux 19 is retained therebetween, thereby enabling flux 19 to be supplied to such an amount that the solder layers 11 are entirely immersed in flux 19, and that the outer leads 7 placed on the solder layers 11 are also immersed in flux at least partially. When the outer leads 7 and the lands 8 are pressed and heated with the bonding tool 13 in this state, solder 20 sufficiently wets the outer leads to suitably connect the outer leads 7 and the lands 8, as shown in Fig. 8B.

In the above-described embodiment, resin frames 15 and 16 are formed on the opposite sides of lands 8 so as to extend through a distance corresponding to the entire length of each array of lands 8. However, if a component other than the resin frames previously provided on the printed circuit board can serve as a means for stopping the flow

of flux on one side of an array of lands 8, resin frames may be formed in such a manner that no resin frame portion is provided on this side of the array of lands 8 while a resin frame portion may be provided only on the opposite side. Also, if the flow of flux can be stopped by some components locally on one or both sides of array of lands 8, corresponding resin frame portions may be removed.

According to the present invention, lands 8 corresponding to outer leads on all the four sides of TCP 3 are connected simultaneously by performing pressing one time and, accordingly, a four-side type bonding tool having a generally-square bottom surface forming an open square space therein. In this embodiment, the four sides of the bottom surface of the above-mentioned bonding tool are formed integrally. However, the bottom configuration of the bonding tool may alternatively be such that four members formed separately from each other are combined to form a square shape. Further, the portion of the bonding tool corresponding to each side of a square shape may be formed of a plurality of members.

As shown in Figs. 9 and 10, only lands 8 are formed in a square frame-like area 21 defined on the printed circuit board 2 in correspondence with the bottom surface configuration of the bonding tool 13, and an upper surface 22 of the printed circuit board 2 is exposed in portions of the area 21 where no lands 8 are formed. In this manner, area 21, in which through holes, wiring patterns, a resist layer, and characters or the like printed on the resist layer by silk screen printing are completely excluded from the arrays of lands 8 and extensions from the same, is provided on the printed circuit board in correspondence with the bottom surface of the bonding tool 13 to ensure that, as shown in Fig. 10, a desired parallelism is maintained between the bottom surface 23 of the bonding tool 13 and the printed circuit board 2 when outer leads 7 of the TCP are pressed by the bottom surface 23. Thus, a possibility of a misalignment of leads at the time of connection is eliminated even in the case of a package part such as a TCP having a particularly fine lead pitch, thereby reliably preventing occurrence of connection failure. Needless to say, wiring patterns or the like may be provided within the area 21 as long as the height of the patterns is low enough to avoid interference with the normal pressing operation of the bonding tool bottom surface 23, that is, lower than the sum of the thicknesses of the lands 8 and the leads 7.

As shown in Fig. 9, on the printed circuit board 2 of the present invention are also provided four marks 25 for positioning the TCP when the TCP is mounted are provided in an area 24 indicated by the double dot-dash line. The area 24 is occupied by the CPU of

the TCP when the TCP is mounted. In this embodiment, one mark 25 is provided at each corner of the area 24 having a generally-square shape. If the TCP is mounted as in the case of the present invention, it is necessary to release heat from the CPU and to connect the CPU to a ground line. To do so, in the area 24, the CPU is bonded and fixed to the printed circuit board in a die bonding manner by using a heat conductive resin, an electroconductive paste or the like. The double dot-dash line in Fig. 9 designates the outer periphery of die pads used for this die bonding or bonding portions.

While inwardly leading signal conductors from the lands and/or through holes can be provided in the area 24 between the lands 8 and the area 24 on the printed circuit board 2, no signal conductors are ordinarily provided in the area 24 except for thermal vias connected to the die pads to as to conduct heat and ground line connections. Therefore, there is no problem in terms of circuit design of the printed circuit board even if positioning marks 25 are provided in this area. Conversely, the degree of freedom of circuit design can be increased by adopting this arrangement. The marks are recognized at a stage before the step of setting the TCP. Therefore, there is no problem even if the marks are provided in the area where the CPU is fixed as in the case of the present invention.

Conventionally, such positioning marks are ordinarily provided in an area outside the lands 8, as indicated at 26 in Fig. 9. Even in a case where such positioning marks are provided inside the lands 8, they are disposed at arbitrary positions on the printed circuit board even in a signal conductor wiring area. According to the present invention, a board area where no signal conductors are arranged is effectively utilized so that the overall size of a semiconductor device can be reduced while the packaging density and wiring density are increased, thus achieving an advantageous effect. Needless to say, the positioning marks in accordance with the present invention can also be applied in the same manner to electronic parts other than TCPs if they are fixed by being bonded to a board.

Marks 25 are formed by patterning copper foil on the printed circuit board as in the case of wiring patterns. Each mark 25 and a region around the mark 25 are not covered with the resist. To improve the recognizability of marks 25, the order of lamination of the printed circuit board 2 is determined while aligning the orientations of layers so that a CuO layer is formed by a blackening treatment on an inner layer of the printed circuit board 2, an inner layer adjacent to the outermost layer in this embodiment. Each mark 25 is thereby made clearly recognizable with an optical sensor or the like, thereby achieving correct and accurate mounting despite of miniaturization and high-

density packaging of semiconductor devices.

Fig. 11 shows a further embodiment of the present invention in which leads are provided only along a pair of opposite sides of an IC package mounted. In this case, an opposed pair of rows of lands 27 are provided on a printed circuit board in correspondence with the leads. In an area 28 defined by the lands 27, two positioning marks 30 are disposed at a diagonal pair of corners of an area 29 corresponding to die pads or bonding portions for bonding and fixing an IC package chip when the IC package is mounted, as in the case of the arrangement described above with reference to Fig. 9. Also in this embodiment, four marks can be respectively disposed at the corners, as in the arrangement shown in Fig. 9. In the embodiment shown in Fig. 9, of the four marks 25, one of two diagonal pairs may be removed.

The preferred embodiments of the present invention have been described in detail. However, as is apparent for those skilled in the art, the present invention comprises other various changes and modifications of the above-described embodiments within its technical scope. For example, cases of mounting a TCP have been described with respect to the embodiments but, needless to say, the present invention can also be applied in the same manner to IC packages having a multiplicity of leads with a fine pitch.

The present invention is arranged as described above to have various advantages described below.

In the printed circuit board in the first aspect of the present invention, when an electronic part such as an SMD or TCP is mounted in a surface mounting manner by soldering, a misalignment is reliably prevented between leads of the electronic part and lands to which the leads are to be connected, so that the leads and the lands can be stably maintained in a good connected condition, thereby achieving an improvement in yield and a reduction in manufacturing cost. In particular, the circuit board can be designed so as to satisfy needs for increasing the packaging density and the wiring density, for forming finer pattern on the board and for reducing the pitch between leads of parts with the recent development of semiconductor devices having highly improved functions.

The electronic parts connection method in the second aspect of the invention ensures that leads of an electronic part can be correctly aligned with solder layers on a printed circuit board even if the pitch of the leads of the electronic parts is reduced and if the patterns on the circuit board are formed more finely, and that the electronic part can be mounted on the circuit board accurately and in a good connected condition by a certain kind of soldering such as reflow soldering or local heating using a bonding tool.

Moreover, the conventional mounting process can be utilized with addition of few process steps. As a result, the productivity can be remarkably improved only by practicing a simple method at a low cost.

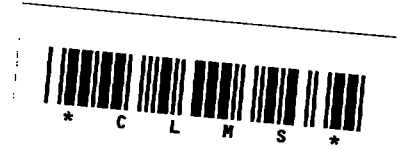
According to the third aspect of the present invention, frames are provided on the printed circuit board to surround lands to enable a sufficient amount of flux to be supplied to a region including lands, whereby leads can be sufficiently immersed in the flux so that the wettability of solder is improved. Therefore, even in the case of connecting a multiple-pin and narrow-pitch part such as a TCP, solder can sufficiently wet leads so that the leads can be soldered in a good connected condition, thus achieving an improvement in yield.

In the case of the printed circuit board in the fifth aspect of the present invention, the desired parallelism of the bottom surface of a bonding tool can always be maintained, so that there is substantially no possibility of misalignment of leads and soldering can be suitably performed even in a case where an electronic part such as a TCP having a small lead pitch is connected.

In the printed circuit board in the sixth aspect of the present invention, positioning marks are provided in an area on a circuit board where die pads or the like for directly fixing an electronic part chip for mounting are disposed, whereby the circuit board area can be effectively utilized without any hindrance to circuit design of the printed circuit board. Therefore, the degree of freedom of circuit board design can be improved and the circuit board can be designed to further reduce the overall size while increasing the density. According to the seventh aspect of the present invention, a multilayer circuit board is provided which has an inner layer processed by a blackening treatment in correspondence with the positions at which positioning marks are provided. The positioning marks can be clearly recognized by the effect of contrast with the inner layer processed by the blackening treatment. It is therefore possible to improve the accuracy with which electronic parts are mounted with the reduction in pattern size and the reduction in lead pitch of the circuit board.

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AMENDED CLAIMS

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1. A printed circuit board comprising:
lands (8) to which leads (7) of at least one electronic part (3) to be mounted are to be connected;
and a solder layer (11) formed on each of the said lands,
wherein the upper surface of the said solder layer is flattened,
and wherein the said solder layers (11) and said lands (8) are covered with removable heat resistant resin material (14), and wherein said resin is an acrylic or UV-curing resin.
2. A method of mounting a plurality of electronic parts on a circuit board having lands corresponding to leads of the electronic parts and further having a solder layer formed on each land, and wherein the plurality of electronic parts includes a tape carrier package type part,

the method comprising the steps of:
 - (i) flattening the upper surface of the solder layer;
 - (ii) placing leads of the plurality of electronic parts on the solder layers of the corresponding lands; and
 - (iii) soldering the leads to their corresponding lands at a time by the use of heat.
3. A method of mounting at least one electronic part on a printed circuit board having lands corresponding to leads of the electronic part, and further having a solder layer formed on each land, the method comprising the steps of:
 - (i) flattening the upper surface of the solder layer;
 - (ii) placing leads of the electronic part on the solder layers; and
 - (iii) heating the leads and the lands to solder and thereby connect them, wherein the leads and the lands are soldered by being pressed simultaneously with the said heating
4. A method as claimed in claim 3, wherein the upper surface of the solder layer is flattened by pressing.
5. A method as claimed in claim 4, wherein said pressing is performed by using at least one roller.
6. A method as claimed in claim 5, wherein the length of said roller is longer than the length of one side of the printed circuit board, and wherein the entire surface of the printed circuit board is pressed at a time.

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7. A method as claimed in claim 5 or 6, wherein the printed circuit board is partially pressed by using the roller.
8. A method as claimed in claim 4, wherein said pressing is performed by using a bonding tool.
9. A method as claimed in claim 8, wherein a plurality of the printed circuit boards are stacked one on another and are pressed at a time by using the bonding tool.
10. A method as claimed in claim 4, wherein said pressing is performed by pinching the printed circuit board between metallic plates.
11. A method as claimed in claim 10, wherein a plurality of the printed circuit boards are stacked one on another and are pressed by using the metallic plates.
12. A method as claimed in claim 10 or 11, wherein the entire surface of the printed circuit board is pressed at a time by using the metallic plates.
13. A method as claimed in claim 10 or 11, wherein the printed circuit board is partially pressed by using the metallic plates.
14. A method as claimed in claim 4, wherein the upper surface of the solder layer is heated simultaneously with said pressing.
15. A method of mounting at least one electronic part on a printed circuit board, wherein the at least one electronic part includes a tape carrier package type part, and wherein the printed circuit board has (a) lands corresponding to leads of the electronic part, and (b) a solder layer formed on each land,

the method comprising the steps of:

- (i) flattening the upper surface of the solder layer;
 - (ii) placing leads of the electronic part on the solder layers;
 - (iii) soldering the lands and the leads by:
 - a) heating; or
 - b) pressing them simultaneously with said heating; and
 - (iv) connecting the tape carrier package type part after a reflow step
16. A method of mounting at least one electronic part on a printed circuit board having lands corresponding to leads of the electronic part and a solder layer formed on each land, the method comprising the steps of:
 - (i) flattening the upper surface of the solder layers;

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- (ii) after step (I), temporarily covering the lands with a heat resistant resin material;
 - (iii) after step (ii) removing the heat resistant resin material;
 - (iv) placing the leads of the electronic part on the solder layers; and
 - (v) connecting the lands and the leads by soldering
17. A printed circuit board comprising:
lands to which leads of at least one electronic part to be mounted are connected;
a solder layer formed on each of said lands; and
at least one frame formed so as to surround said lands and so as to be higher than said solder layer.
18. A printed circuit board as claimed in claim 21, wherein said frame is formed by silk screen printing.
19. A method of mounting at least one electronic part on the printed circuit board as claimed in claim 21, comprising the steps of:
supplying flux to a region surrounded by the frame;
placing the leads of the electronic part on the solder layers so that the leads are immersed at least partially in the flux; and
pressing and heating the leads, the solder layers and the lands to connect the lands and the leads.
20. A printed circuit board comprising:
lands to which leads of at least one electronic part to be mounted are connected by being pressed with a bonding tool; and
a region lower in height than said lands and provided in an area corresponding to a bottom surface of said bonding tool.
21. A printed circuit board according to claim 24, wherein said electronic part has leads arranged along its four sides, and said region is provided in a rectangular frame like area which corresponds to said leads and in which said lands are located.
22. A printed circuit board comprising;
(i) a substrate on which at least one electronic part chip is mounted; and
(ii) marks for positioning the electronic part chip when the chip is mounted,
wherein said substrate has a multilayer structure having an inner layer processed by a blackening treatment at positions corresponding to said positioning marks.
23. A printed circuit board as claimed in claim 22, comprising;
wherein said positioning marks are provided inside a region of said substrate to which the electronic part chip is directly fixed.