

METHOD OF MANUFACTURING INTEGRATED CIRCUIT MODULES

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to integrated circuit (IC) modules, and more particularly, to
5 a method for manufacturing IC modules which can allow the manufactured IC modules to
be more compact and also can help reduce the manufacturing cost of the IC modules.

2. Description of Related Art:

An integrated circuit (IC) module is a collection of a number of functionally
related IC chips on a single printed circuit board (PCB) for simplified and easy
10 maintenance, replacement, and storage. Commonly used IC modules include, for
example, DRAM modules, Flash ROM modules, network-related modules, and so on.
Conventionally, these IC chips are mounted on the PCB in packaged form. Since
packaged IC chips are large in size and require complex manufacturing process to
construct, the overall manufacturing cost is very high. Moreover, since the packaging
15 process for the IC chips and the assembly process for mounting them on the PCB are
separately carried out at different sites, the complexity of the overall manufacturing
process for the IC modules is further increased. One example of a conventional method
for manufacturing IC modules is depicted in the following with reference to FIGs. 1A-1C
and FIG. 2

20 Referring to FIG. 1A, in the first step of the conventional method, a PCB 10 is
prepared. This PCB 10 is designed with a circuit layout for the mounting of a number of
packaged IC chips thereon.

Referring next to FIG. 1B, a number of packaged IC chips 14 are mounted on the
PCB 10 through a solder assembly process which permanently joints the pins 16 on the
25 packaged IC chips 14 to corresponding soldering pads on the PCB 10.

Referring further to FIG. 1C, an assembly of auxiliary circuit elements 18,

including resistors and/or capacitors, is mounted on the PCB 10. This completes the manufacture of the IC module 12.

FIG. 2 is a flow diagram showing the steps involved in a manufacturing process in relation to the foregoing method of FIGs. 1A through 1C for manufacturing the IC module 12. As shown, the manufacturing process includes six steps: IC fabrication, IC
5 packaging, IC burn-in and testing, manufacturing PCB, module assembly, and module testing. Since the IC chips 14 mounted on the PCB 10 are in packaged form, they should undergo the steps of IC fabrication, IC packaging, and IC burn-in and testing before they can mounted on the PCB 10. Moreover, the steps of IC fabrication, IC packaging, and IC
10 burn-in and testing are carried out at one site and the steps of module assembly and module testing are carried at another site. The overall manufacturing process for the IC modules is therefore quite complex in procedure and thus very costly to carry out.

Another conventional method involves the use of the so-called chip-on-board (COB) technique, which can help reduce the manufacturing cost of the IC modules.
15 However, this method is not quite reliable to use and is still quite complex in procedure. Therefore, it is still not widely utilized in the industry.

SUMMARY OF THE INVENTION

It is therefore a primary objective of the present invention to provide a method of
20 manufacturing IC modules which involves the use of the more advanced chip-array package technique that can allow the overall manufacturing process to be simplified.

It is another objective of the present invention to provide a method of manufacturing IC modules which can help provide compact and low-cost IC modules.

In accordance with the foregoing and other objectives of the present invention, a
25 new method of manufacturing IC modules is provided. In the method of the invention, the first step is to prepare a printed circuit board (PCB) on which the IC module is to be constructed. The second step is to mount a plurality of IC chips on the PCB. The third

step is to perform a wire bonding process to electrically connect the IC chips to the PCB via gold or aluminum wires. A burn-in process and a chip-probe testing process can be included to check for any defects in the IC chips before proceeding to the ensuing encapsulation process.

5 Subsequently, the fourth step is to perform an encapsulation process so as to coat an encapsulation layer over the entire top surface of the PCB, covering all of the IC chips and their associated bonding wires. The encapsulation layer is then subjected to a drying and curing process so as to harden it. The fifth step is to perform a photolithographic and etching process for selective removal of the encapsulation layer. The sixth step is to
10 mount an assembly of auxiliary circuit elements (to the IC chips) in the exposed areas on the PCB. Moreover, the method includes the steps of performing a pre-cut testing process on the IC modules; then cutting the IC modules apart from the PCB; and finally performing a post-cut module testing process on the cut-apart IC modules.

 The foregoing method involves the use of the advanced chip-array package
15 technique that can help simplify the overall manufacturing process and allow the resultant IC modules to be made compact. The manufacturing cost of the IC modules can thus be significantly reduced.

BRIEF DESCRIPTION OF DRAWINGS

20 The invention can be more fully understood by reading the following detailed description of the preferred embodiments, with reference made to the accompanying drawings, wherein:

 FIGs. 1A through 1C are schematic sectional diagrams used to depict the steps involved in a conventional method for manufacturing an IC module;

25 FIG. 2 is a flow diagram showing the steps involved in a manufacturing process in relation to the method of FIGs. 1A through 1C for manufacturing an IC module;

 FIGs. 3A through 3F are schematic sectional diagrams used to depict the steps

involved in the method according to the invention for manufacturing an IC module; and

FIG. 4 is a flow diagram showing the steps involved in a manufacturing process in relation to the method of FIGs. 3A through 3F for manufacturing an IC module.

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DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIGs. 3A through 3F are schematic sectional diagrams used to depict the steps involved in the method according to the invention for manufacturing an IC module.

Referring to FIG. 3A, in the first step, a printed circuit board (PCB) 30, such as a
10 PCB of 10×10 square inch in size, preferably made from the BT resin, is prepared. The PCB 30 is partitioned into an array of areas, referred to as module array, on which an array of IC modules 32 are to be constructed together on the PCB 30. To simplify the drawings, only one of the IC modules 32 is shown in the ensuing FIGs. 3B through 3F in sectional views.

15 Referring next to FIG. 3B, in the subsequent step, a number of IC chips 34 are mounted on the PCB 30 through the conventional die attach method.

Referring further to FIG. 3C, a plurality of bonding wires 36, such as gold or aluminum wires, are used for electrical connection between the bonding pads (not shown) on the IC chips 34 and the copper pads (not shown) on the PCB 30 through a
20 conventional wire bonding process.

Referring further to FIG. 3D, the subsequent step is to perform an encapsulation process so as to coat an encapsulation layer 38 over the entire top surface of the PCB 30, enclosing all of the IC chips 34 and their associated bonding wires 36 therein. The encapsulation layer 38 is formed by applying an encapsulation material, such as a liquid
25 type polymer with the trademark Hysol 4450, over the entire top surface of the PCB 30 through either a doctor blade, or a spin coating, or a dropping process. Preferably, the polymer used to form the encapsulation layer 38 has a photo-sensitive property (the

reason for this will be described later). After this, the PCB 30 is subjected a drying and curing process so as to harden the encapsulation layer 38.

Prior to the encapsulation process, a burn-in process and a chip-probe testing process can be performed so as to check for any defects in the IC chips 34. If any detected
5 IC chips are found, they can be repaired immediately before proceeding to the ensuing encapsulation process.

Referring further to FIG. 3E, in the subsequent step, a photolithographic and etching process is performed to remove selected portions of the encapsulation layer 38 so as to expose those regions on the PCB 30 where additional circuit elements are to be
10 mounted, with the remaining portions of the encapsulation layer 38 still covering all of the IC chips 34 and their associated bonding wires 36.

If the encapsulation layer 38 is photo-sensitive in nature, the photolithographic process will involve only the steps of positioning a mask (not shown) on the encapsulation layer 38 and then subjecting the encapsulation layer 38 to light exposure
15 through the mask (not shown). Otherwise, the photolithographic process requires an additional step of coating a layer of photo-sensitive material, such as a photoresist layer, over the encapsulation layer 38. This will add one more step to the overall manufacturing process. Therefore, as mentioned earlier, the encapsulation layer 38 is preferably formed directly from a photo-sensitive polymer.

20 Referring to FIG. 3F, in the subsequent step, an assembly of auxiliary circuit elements 40 to the IC chips 34, including an assembly of resistors and/or capacitors, is mounted on the PCB 30. This completes the manufacture of the IC module 32.

After this, a pre-cut testing process, such as a chip-probe (CP) testing process, is performed on the IC module 32 to test the IC chips 34 therein. Then, each one of the
25 array of IC modules 32 on the PCB 30 (FIG. 3A) is cut apart to serve as a single IC module. After this, a post-cut testing process, which is a conventional module testing process, is performed on the cut-apart IC modules so as to check the good-yield rate

thereof. All the ensuing processes involve only conventional techniques so description thereof will not be further detailed.

FIG. 4 is a flow diagram showing the steps involved in a manufacturing process in relation to the method of FIGs. 3A through 3F for manufacturing the IC modules 32. As shown, the step 42 is to prepare the PCB 30 (FIG. 3A); the step 44 is used for IC fabrication to provide the IC chips 34. The step 46 is to mount the IC chips 34 on the PCB 30 through a conventional die attach method (FIG. 3B). The step 48 is to perform a conventional wire bonding process to connect the bonding wires 36 between the IC chips 34 and the PCB 30 (FIG. 3C). After this, the IC chips 34 can undergo a burn-in process and a CP testing process in step 49; and if any defected IC chips are found, they are repaired in the step 51.

The subsequent step 50 is to perform the encapsulation process to form the encapsulation layer 38 over the entire top surface of the PCB 30, enclosing all of the IC chips 34 and their associated bonding wires 36 therein (FIG. 3D). Next, the step 52 is to perform a photolithographic and etching process for selective removal of the encapsulation layer 38 (FIG. 3E). The next step 54 is to mount the assembly of circuit elements 40 on the PCB 30. (FIG. 3F). In the step 56, the manufacture of the IC modules 32 is completed.

The subsequent step 58 is to perform the pre-cut testing process to test the IC module 32 before cutting them apart from the PCB 30. In the step 60, the IC modules 32 are cut apart so each serves as a single IC module. The final step 62 is the post-cut testing process (module testing) on each separate IC module.

In conclusion, the invention has several advantages over the prior art. First, it allows the manufacturing process to be completed at a single site, which can significantly shorten the time needed to complete the manufacturing process. Compared to the prior art which requires the manufacturing process to be separately carried out at different sites, the invention is obviously more advantageous to use. Second, the encapsulation process

used in the method of the invention allows the resultant IC modules to occupy smaller spaces on the printed circuit board. The manufactured IC modules are thus smaller in size. Moreover, the use of the BT resin and soft gold wires on the PCB allows the wire bonding process to be performed through thermosonic means, which can provide more reliability than the conventional COB method. Third, the encapsulation process used in the method of the invention allows the elimination of the step of packaging the IC chips as is required in conventional methods using the COB technique, so that the overall manufacturing process can be further simplified.

The invention has been described using exemplary preferred embodiments. However, it is to be understood that the scope of the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements. The scope of the claims, therefore, should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.



CLAIMS

What is claimed is:

1. A method for manufacturing an IC module, comprising the steps of:
 - (1) preparing a printed circuit board on which the IC module is to be constructed;
 - 5 (2) mounting a plurality of IC chips on the printed circuit board;
 - (3) connecting a plurality of bonding wires to electrically connect the IC chips to the printed circuit board;
 - (4) performing an encapsulation process so as to coat an encapsulation layer over the entire top surface of the printed circuit board, covering all of the IC chips and
10 associated bonding wires;
 - (5) removing selected portions of the encapsulation layer so as to expose those areas on the printed circuit board where an assembly of auxiliary circuit elements to the IC chips are to be mounted, with the remaining portions of the encapsulation layer still covering all of the IC chips and associated bonding wires; and
15 (6) mounting the assembly of auxiliary circuit elements in the exposed areas on the printed circuit board.
2. The method of claim 1, wherein the printed circuit board is partitioned into a module array layout for the construction of an array of IC modules thereon.
3. The method of claim 1, wherein the printed circuit board is 10×10 square inch in
20 size made from BT resin.
4. The method of claim 1, wherein in said step (2), the IC chips are mounted on the printed circuit board through a die attach process.
5. The method of claim 1, wherein in said step (3), the bonding wires are gold wires connected through a wire bonding process.
- 25 6. The method of claim 1, further comprising the step of performing a burn-in process and a chip-probe testing process on the IC chips prior to the encapsulation process.



7. The method of claim 1, wherein in said step (4), the encapsulation process includes the steps of:
- coating a liquid type polymer over the entire top surface of the printed circuit board to form the encapsulation layer; and
- 5 subjecting the encapsulation layer to a drying and curing process so as to harden the encapsulation layer.
8. The method of claim 7, wherein said coating step is carried out by performing a doctor blade process.
9. The method of claim 7, wherein said coating step is carried out by performing a
- 10 spin coating process.
10. The method of claim 7, wherein said coating step is carried out by performing a dropping process.
11. The method of claim 1, wherein in said step (5), the selective removal of the encapsulation layer is carried out by performing a photolithographic and etching process.
- 15 12. The method of claim 1, further comprising the steps of:
- performing a pre-cut testing process on the IC module;
- cutting the IC module apart from the printed circuit board; and
- performing a post-cut module testing process on the cut-apart IC module.
13. The method of claim 12, wherein the pre-cut testing process is a chip-probe
- 20 testing process.
14. A method for manufacturing a plurality of IC modules, comprising the steps of:
- (1) preparing a printed circuit board which is partitioned into a module array layout on which the IC modules are to be constructed;
- (2) performing a die-attach process so as to mount a plurality of IC chips on the
- 25 printed circuit board;
- (3) performing a wire bonding process so as to connect a plurality of bonding wires to electrically connect the IC chips to the printed circuit board;



(4) performing a burn-in and testing process on the IC chips;

(5) performing an encapsulation process so as to coat an encapsulation layer over the entire top surface of the printed circuit board, covering all of the IC chips and associated bonding wires;

5 (6) performing a photolithographic and etching process for selective removal of the encapsulation layer so as to expose those areas on the printed circuit board where an assembly of circuit elements is to be mounted, with the remaining portions of the encapsulation layer still covering all of the IC chips and associated bonding wires;

 (7) mounting the assembly of circuit elements on the exposed areas on the printed
10 circuit board;

 (8) performing a pre-cut testing process on the IC modules;

 (9) cutting the IC modules apart from the printed circuit board; and

 (10) performing a post-cut testing process on the cut-apart IC modules.

15 15. The method of claim 14, wherein the printed circuit board is 10×10 square inch in size made from BT resin.

16. The method of claim 14, wherein in said step (5), the encapsulation process includes the steps of:

 coating a liquid type polymer over the entire top surface of the printed circuit board to form the encapsulation layer; and

20 subjecting the encapsulation layer to a drying and curing process so as to harden the encapsulation layer.

17. The method of claim 14, wherein said coating step is carried out by performing a doctor blade process.

18. The method of claim 14, wherein said coating step is carried out by performing a
25 spin coating process.

19. The method of claim 14, wherein said coating step is carried out by performing a dropping process.