

RIGID-FLEX PRINTED CIRCUIT BOARDS

BACKGROUND OF THE INVENTION

The present invention is related to the field of printed circuit boards.

Rigid-flex circuit boards have been fabricated so that they have the desirable characteristics of both rigid and flexible circuits. The rigid areas of the rigid-flex boards are used for mounting circuit components, attaching external cables via connectors, and providing electrical circuit interconnections among the components and connectors. The relatively flexible areas of the rigid-flex boards are used to carry electrical interconnections and to enable the board to be bent as required by the physical characteristics of the product in which the board is to be used.

Rigid-flex circuit boards have a variety of structures. One type of multilayer rigid-flex circuit boards is disclosed in U.S. Pat. No. 6,350,387. The disclosed rigid flex circuit board is composed of a series of alternating insulating insulative and conductive layers. Portions of the outer layers have been selectively removed so as to produce a relatively thinner, flexible region. One problem with this type of rigid flex circuit boards is that the flex core extends across the entire circuit board, both in the flexible and rigid parts of the circuit board. This results in the flex area being similar in material as in the rigid portion of the circuit board. Therefore, this type of circuit board is not as flexible as a circuit board that has only flexible material in the flexible portion of the circuit boards.

Another type of rigid-flex circuit board is disclosed in U.S. Pat. No.

4,800,461. This patent discloses a rigid flex circuit board composed of a basestock laminated on both sides to two insulator prepeg sheets that have cutouts. A flexible insulator KAPTON (available from Dupont company) is positioned over each cutout to produce the flexible region for the circuit board. This circuit board also has limited flexibility because the flex core extends across the whole circuit board, both in the flexible and rigid parts of the circuit board.

Yet another type of multilayer rigid-flex circuit boards is disclosed in U.S. Pat. No. 5,723,205. This patent discloses a multilayer rigid-flex circuit board having a double-sided basestock composite. The basestock composite is composed of two inner insulator sheets containing a flexible core sandwiched between two outer conductive sheets. One drawback associated with this rigid flex circuit boards is that the process for forming the flexible core is relatively difficult because of the step profile of the flexible core.

There remains a need in the art for a multilayer rigid-flex printed circuit board that has improved ductility or flexibility, yet simple in construction.

SUMMARY OF THE INVENTION

The present invention is directed to a multilayer rigid-flex printed circuit board comprising a basestock composite with a flexible insert. The basestock composite is composed of a core insulating layer sandwiched between two conductive sheets. The core insulating sheet has a cutout region that is filled with a flexible insert, wherein the cutout region has substantially vertical sidewalls. Furthermore, the side edges of the flexible insert do not have a step profile.

The advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a cross-sectional view of a basestock composite according to an embodiment of the present invention.

FIG. 2 shows a cross-sectional view of a basestock composite according to another embodiment of the present invention.

FIGS. 3-8 show six different embodiments for the rigid-flex printed circuit board of the present invention.

FIGS. 9-12 show four additional embodiments of the rigid-flex printed circuit board of the present invention, in which the printed circuit board is provided with solder masks.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The basestock composite 1 of the present invention is shown in FIG. 1. The basestock composite 1 comprises a core insulating layer 2 sandwiched between two conductive sheets 3 and 4. The core insulating layer 2 contains a flexible insert 5 that is formed in a cutout region. The core insulating layer 2 is made of a conventional insulation material, for example, fiber glass impregnated with an epoxy, commonly referred to as a "prepeg." Other suitable insulation materials include aramid fibers (e.g. "THERMOUNT" from DuPont company),

polytetrafluoroethylene (PTFE)-based materials, and polyimide. The flexible insert 5 may be made of a polyimide such as KAPTON or a flexible solder mask material. As can be seen in FIG. 1, the side edges of the insert do not have a step profile. The conductive sheets 3 and 4 are preferably made of copper, but it should be understood that other metals or conductive materials are possible.

In an alternative embodiment shown by FIG. 2, the core insulating layer 2 is composed of two coextensive insulating layers 2a and 2b, which are made of the same insulation materials.

FIGS. 3-5 show different embodiments of a stack laminate comprising the basestock composite 1. The basestock composite 1 is the same as that described in FIG. 1. In these embodiments, the basestock composite 1 is sandwiched between two outer insulating layers 6 and 7, wherein the outer insulating layers have cutout regions that contain flexible inserts 8 and 9, respectively. The flexible inserts 8 and 9 may be made of KAPTON or a flexible solder mask, and the outer insulating layers may be made of prepeg material or material similar to inserts 8 and 9. In the embodiment shown in FIG. 3, the exposed surfaces of the outer insulating layers 6 and 7 are substantially coplanar with the exposed surfaces of the flexible inserts 8 and 9. In addition, the flexible inserts 8 and 9 are substantially aligned with flexible insert 5, but the side edges of the flexible inserts 5, 8 and 9 are staggered relative to each other so as to compensate for the weak areas at the boundaries between the flexible inserts and the insulating layers. Referring to FIG. 4, the flexible inserts 8 and 9 are made to be slightly larger than the corresponding cutout regions in the outer insulating layers 6 and 7, and each

of the flexible inserts 8 and 9 overlaps a portion of the corresponding insulating layer at the cutout region. In the embodiment shown in FIG. 5, the flexible inserts 8 and 9 are made to be slightly larger than the corresponding cutout regions, but each flexible insert is formed under the corresponding cutout region so that the insulating layer overlaps a portion of the flexible insert at the cutout region.

FIG. 6 shows an exemplary embodiment in which the stack laminate shown in FIG. 3 is stacked to another similar laminate so as to form a hollow region 10. The stack laminate shown in FIG. 3 is designated as stack laminate 20 in FIG. 4. A second stack laminate 30 is stacked to the stack laminate 20 by the use of central insulating layer 11 with a hollow region 10. The second stack laminate 30 is similar to the stack laminate 20 in construction.

FIG. 7 shows another embodiment of a printed circuit board comprising the basestock composite 1. In this embodiment, the basestock composite 1 is laminated to two outer prepreg layers 21 and 23. The outer prepreg layers 21 has a cutout region 27 that contains a flexible insert 22. The outer prepreg layer 23 has a cutout region 28 that contains a flexible insert 24. An outer conductive sheet 25 is laminated to the outer surface of the outer prepreg layer 21, and another outer conductive sheet 26 is laminated to the outer surface of the outer prepreg layer 23. The outer conductive sheets 25 and 26 also have cutout regions that correspond with the cutout regions 27 and 28 in the outer prepreg layers 21 and 23. The cutout regions 27, 28 and the flexible inserts 5, 22, 24 are substantially aligned so as to define the flexible region of the rigid-flex printed circuit board.

FIG. 8 shows another embodiment of a printed circuit board according to

present invention. In this embodiment, a core insulating layer 33 is sandwiched between conductive sheets 35 and 36. The core insulating layer 33 contains a flexible insert 34 that is formed in a cutout region in the core insulating layer 33. The conductive sheet 35 is further bonded to an outer insulating layer 31, which also has a flexible insert 32. The conductive sheet 36 is further bonded to an outer insulating layer 37. A surface of the flexible insert 34 is exposed by an opening 38 formed through the outer insulating layer 37 and the conductive sheet 36.

In the embodiments shown in FIGS. 9-11, the basestock composite 1 is sandwiched between two outer layers 40 and 41, wherein the outer layers have cutouts that contain solder masks 42 and 43. Referring to FIG. 9, the cutouts in the outer layers 40 and 41 are filled with solder masks 42 and 43, respectively, so that the outer surfaces of the outer layers 40 and 41 are substantially coplanar with the outer surfaces of solder masks. The outer layers 40 and 41 may be made of materials similar to solder masks 42 and 43, e.g. flexible solder masks or photoimageable materials, or materials different from the solder masks 42 and 43. In another embodiment shown in FIG. 10, each solder mask is made to be slightly larger than the corresponding cutout and the solder mask overlaps a portion of the outer layer at the cutout area. In the embodiment shown in FIG. 11, each solder mask is made to be larger than the corresponding cutout, but the solder mask is formed under the cutout so that the outer layer overlaps a portion of the solder mask at the cutout area.

In yet another embodiment shown in FIG. 12, the basestock composite 1 is

laminated on opposite sides to a plurality of prepreg layers 44a, 44b, 46a, 46b, and conductive sheets 45a, 45b, 47a, 47b, with the prepreg layers alternating with the conductive sheets. Cutout regions 54 and 55 are formed through the prepreg layers 44a, 44b, 46a, 46b and conductive sheets 45a, 45b, 47a, 47b to define the flexible region of the printed circuit board. As can be seen from FIG. 12, the cutout regions 54 and 55 are substantially aligned with the flexible insert 5. Solder masks 52 and 53 are formed over the exposed surfaces.

It is preferred that a flexible solder mask material is used in the embodiments shown by FIGS. 9-12. An example of a suitable solder mask is an epoxy-based material known by the trademark PALCOAT®. Another example is a photo-imageable solder mask sold under the trademark Imageflex™.

Even though prepreg layers have been described in FIGS. 7-12, it should be understood by one skilled in the art that other insulating materials, e.g. aramid fibers, may be used in place of the prepreg material.

The rigid-flex circuit boards of the present invention have excellent ductility and flexibility, yet simple in construction. Because of these characteristics, the rigid-flex boards of the present invention are particularly suitable for dynamic flexing.

While the preferred embodiments have been described above, it should be understood that other variations may be made therein by one skilled in the art without departing from the spirit and scope of the invention.

CLAIMS

1. A rigid-flex printed circuit board comprising:
a basestock composite comprised of a core insulating layer sandwiched between two conductive sheets, the core insulating layer having a cutout region that is filled with a core flexible insert,
wherein the cutout region has substantially vertical sidewalls.
2. The rigid-flex printed circuit board of claim 1, wherein the sidewalls of the cutout region do not have a step profile.
3. The rigid-flex printed circuit board of claim 1, wherein the core insulating layer is comprised of two thinner insulating layers.
4. The rigid-flex printed circuit board of claim 1, wherein the core flexible insert comprises polyimide or flexible solder mask.
5. The rigid-flex printed circuit board of claim 1, wherein the core insulating layer comprises an insulation material selected from the group consisting of fiberglass impregnated with an epoxy, fiberglass impregnated with polyimide, polytetrafluoroethylene-containing material, and aramid-containing material.

6. The rigid-flex printed circuit board of claim 1, wherein the conductive sheets are made of copper.
7. The rigid-flex printed circuit board of claim 1 further comprising:
 - a first outer insulating layer having a first cutout region that contains a second flexible insert; and
 - a second outer insulating layer having a second cutout region that contains a third flexible insert,wherein the basestock composite is laminated between the first outer insulating layer and the second outer insulating layer, and the core flexible insert is substantially aligned with the second flexible insert and the third flexible insert.
8. The rigid-flex printed circuit board of claim 6, wherein the side edges of the core flexible insert, the side edges of the second flexible insert, and the side edges of the third flexible insert are staggered relative to one another.
9. The rigid-flex printed circuit board of claim 6, wherein the second flexible insert overlaps a portion of the first outer insulating layer at the second cutout region, and the third flexible insert overlaps a portion of the second outer insulating layer at the third cutout region.
10. The rigid-flex printed circuit board of claim 6, wherein the first outer insulating layer overlaps a portion of the second flexible insert at the second cutout

region, and the second outer insulating layer overlaps a portion of the third flexible insert at the third cutout region.

11. The rigid-flex printed circuit board of claim 6, wherein the first outer insulating layer has two outer surfaces, each of which being substantially coplanar with an outer surface of the second flexible insert, and the second outer insulating layer has two outer surfaces, each of which being substantially coplanar with an outer surface of the third flexible insert.

12. The rigid-flex printed circuit board of claim 1 further comprising:

a first outer layer having a cutout region that contains a first solder mask;

and

a second outer layer having a cutout region that contains a second solder mask,

wherein the basestock composite is laminated between the first outer layer and the second outer layer, and the core flexible insert is substantially aligned with the first solder mask and the second solder mask.

13. The rigid-flex printed circuit board of claim 12, wherein the first and second outer layers are made of materials similar to the first and second solder masks.

14. The rigid-flex printed circuit board of claim 12, wherein the first and second outer layers are made of materials different from the first and second solder masks.

15. The rigid-flex printed circuit board of claim 1 further comprising:

a first multilayer stack comprised of alternating layers of insulating material and conductive material laminated to one side of the basestock composite, said first multilayer stack having a first opening that exposes a first portion of the basestock composite;

a second multilayer stack comprised of alternating layers of insulating material and conductive material laminated to the opposite side of the basestock composite, said second multilayer stack having a second opening that exposes a second portion of the basestock composite; and

solder mask films covering the exposed surfaces in the first and second openings, the exposed horizontal surface of the first multilayer stack and the exposed horizontal surface of the second multilayer stack,

wherein the core flexible insert is substantially aligned with the first and second openings.

16. The rigid-flex printed circuit board of claim 1 further comprising:

a first outer insulating layer having a cutout region that contains a second flexible insert;

a second outer insulating layer having a cutout region that contains a third

flexible insert, wherein the basestock composite is sandwiched between the first outer insulating layer and the second outer insulating layer;

a first outer conductive sheet laminated to an outer horizontal surface of the first outer insulating layer; and

a second outer conductive sheet laminated to the an outer horizontal surface of the second outer insulating layer.

17. A rigid-flex printed circuit board comprising:

(a) a first stack laminate comprised of a first basestock composite sandwiched between first and second insulating layers, said first basestock composite comprising a first core insulating layer sandwiched between first and second conductive sheets, said first core insulating layer having a cutout region that is filled with a first flexible insert, wherein the cutout region in said first core insulating layer has substantially vertical sidewalls;

(b) a second stack laminate comprised of a second basestock composite sandwiched between third and fourth insulating layers, said second basestock composite comprising a second core insulating layer sandwiched between third and fourth conductive sheets, said second core insulating layer having a cutout region that is filled with a second flexible insert, wherein the cutout region in said second core insulating layer has substantially vertical sidewalls;

(c) a central insulating layer having a cutout region, said central insulating

layer being sandwiched between the first stack laminate and the second stack laminate so that a hollow region is defined between said first stack laminate and said second stack laminate.

18. The rigid-flex printed circuit board of claim 1, wherein the first insulating layer has a cutout region that is filled with a third flexible insert, the second insulating layer has a cutout region that is filled with a fourth flexible insert, the third insulating layer has a cutout region that is filled with a fifth flexible insert, the fourth insulating layer has a cutout region that is filled with a sixth flexible insert, and the first through sixth flexible inserts are substantially aligned relative to one another.

19. A rigid-flex printed circuit board comprising:

a core insulating layer having a first cutout region that is filled with a first flexible insert, the first cutout region having substantially vertical sidewalls;

a first outer insulating layer having a second cutout region that is filled with a second flexible insert, the second cutout region having substantially vertical sidewalls;

a first conductive sheet sandwiched between the core insulating layer and the first outer insulating layer;

a second conductive sheet having a third cutout region; and

a second outer insulating layer having a fourth cutout region,

wherein the second conductive sheet is laminated between the core

insulating layer and the second outer insulating layer so that the third cutout region in the second conductive sheet exposes at least a portion of the first flexible insert, and the fourth cutout region is aligned with the third cutout region.