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Ground Plane Routing

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Field of the Invention

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The present invention relates generally to flexible circuits and, more particularly, to flexible circuits to which an array of solder spheres are attached to form a ball grid array package for integrated circuits.

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Background of the Invention

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The ability to place solder balls onto vias on a double-sided flexible substrate and mass reflow these solder balls in a conveyor oven would be a rapid and low cost method of attaching the solder balls to the substrate. This procedure, however, is not currently possible since many of the vias are connected directly to the ground plane and so when a solder ball is placed onto the via and heated, it collapses and spills from the via onto the ground plane. The current procedure for attaching solder balls to double-sided metal circuitry is to weld the solder balls onto the vias one at a time with controlled pulse heating. This method produces good results but is slow and costly. Another method is to selectively deposit a solder mask onto the ground plane before mass reflow to prevent spilling of solder at ground plane vias. However, this method adds a process step and is also costly.

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Summary of the Invention

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The present invention allows mass reflow connection of solder balls to metallized vias on a two metal layer flexible substrate (such as polyimide) by preventing collapse of the solder ball. In this construction, a polyimide window is created around each via on the ground plane side of the substrate. This window acts as a solder dam which prevents collapse of the solder ball.

1 In instances where the solder ball needs to be
2 electrically connected to the ground plane, this is done
3 by routing from the solder ball via to the circuit side
4 and back down to the ground plane through another via
5 located at a distance from the solder ball. This design
6 can be carried out with either through hole or blind
7 vias.

8 This design allows attachment of solder balls to
9 flexible circuitry by the more efficient and less costly
10 process of mass reflow. For example, solder balls can be
11 placed in position on the flexible circuitry and held in
12 place with a sticky flux as the circuit passes through a
13 conveyor oven to reflow the solder and attach the balls.
14 The flexible circuitry can then be soldered to the
15 circuit board using standard processes known in the
16 surface mount industry.

17 In general terms the invention is a flexible circuit
18 structure capable of mass reflow attachment of solder
19 balls to a ground plane thereof including a flexible
20 polymeric base having two major surfaces, a first metal
21 coating defining a ground plane disposed on one major
22 surface of the base, a second metal coating defining
23 circuit traces on the other major surface of the base, a
24 clear area on the first major surface free of the first
25 metal coating and sufficiently large so as to accept a
26 solder ball disposed therein without contact between the
27 first metal coating and the solder ball, a hole in the
28 clear area through the base and communicating with the
29 second metal coating; a via connecting the first and the
30 second metal coatings through the base and removed from
31 the clear area, and a circuit trace of the second metal
32 coating extending from the hole to the via. This
33 construction allows a solder ball placed in the hole to
34 be mass reflow attached to the second metal coating
35 through the hole while remaining free of direct physical
36 contact with the first metal surface, but while being in
37 electrical contact with the first metal coating through

1 the circuit trace extending from the hole to the via and
2 then through the via.

3 In more particular terms, the preferred embodiment
4 of the invention is a flexible circuit structure capable
5 of mass reflow attachment of solder balls to a ground
6 plane thereof and includes a flexible, polymeric base; a
7 first conductive coating defining a ground plane disposed
8 on one side of the base; a second conductive coating
9 defining circuit traces on the other side of the base; a
10 first via connecting the first conductive coating and the
11 second conductive coating; a second via connecting the
12 first conductive coating and the second conductive
13 coating, the second via being removed from the first via;
14 an area completely surrounding the first via free of the
15 first conductive coating; a circuit trace defined by the
16 second conductive coating electrically connected to the
17 first via and leading to the second via. By means of
18 this construction, a solder ball placed in the first via
19 on the first conductive coating of the flexible circuit
20 may be mass reflow soldered to the first via while
21 remaining free of physical contact with the first
22 conductive surface surrounding the first via, but while
23 remaining in electrical contact with the first conductive
24 surface surrounding the first via through the circuit
25 trace and the second via.

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27 Brief Description of the Drawings

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29 The present invention will be described with respect
30 to the accompanying drawings, wherein like numbers refer
31 to like parts in the several views, and wherein:

32 Figure 1 is a plan view of a portion of a flexible
33 circuit according to the prior art illustrating a via
34 connected to the ground plane;

35 Figure 2 is a view similar to that of Figure 1 with
36 a solder ball placed on the via;

37 Figure 3 is a view similar to those of Figures 1 and
38 2 after mass reflow of the solder ball;

1 Figure 4 is a plan view of the ground plane side of
2 a flexible circuit according to the present invention;

3 Figure 5 is a cross-sectional view of the flexible
4 circuit of Figure 4 taken generally along the line 5-5 of
5 Figure 4;

6 Figure 6 is a view similar to that of Figure 5 with
7 solder balls in place; and

8 Figure 7 is a cross-sectional view similar to Figure
9 6 of an alternate embodiment of a flexible circuit
10 according to the invention.

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12 Description of the Preferred Embodiment

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14 Figures 1 through 3 illustrate an attempt to mass
15 reflow solder a solder ball to the ground plane of a
16 flexible circuit by conventional means. In these
17 Figures, a portion of a conventional flexible circuit,
18 generally indicated as 10, is illustrated. The flexible
19 circuit 10 includes a polymeric, usually polyimide,
20 central base lamination 12, a first conductive coating
21 usually of metal, and preferably copper, on one side of
22 the base 12 and defining a ground plane 14 and a second
23 coating (not shown) of metal on the opposite side of the
24 base 12 defining circuit traces. To attempt to mass
25 reflow a solder ball 16 to this ground plane 14, as large
26 an area as practical of the ground plane 14 is removed in
27 an attempt to prevent unwanted flow of the solder ball
28 16. Unfortunately, Figure 3 illustrates that upon
29 heating the solder ball 16 does not remain in the desired
30 central location, but rather collapses and flows along
31 the connecting traces to the ground plane 14 to flood the
32 ground plane 14. It will be noted that the collapsed
33 solder ball 16 does not wet the polyimide base 12 very
34 well, and flows around the exposed base 12 portions.

35 Figures 4 through 6 illustrate an improved
36 construction of a flexible circuit 20 according to the
37 present invention which allows solder balls to be mass
38 reflow soldered to the ground plane 22 without collapsing

1 and flooding the ground plane 22. At locations such as
2 24 where it is desired to attach a solder ball 26, an
3 entire circular disk of the first metal coating defining
4 the ground plane 22 is removed (or not deposited in the
5 first instance) to expose the polyimide base lamination
6 28. Within the exposed area of the base 28, a via 30 is
7 constructed which connects to the second coating of metal
8 on the side of the base 28 which define individual
9 circuit traces 34. Those familiar with flexible circuit
10 20 construction methods will recognize that the above
11 description is presented for conceptual purposes only.
12 In actuality, the via 30 will be formed along with the
13 ground plane 22 by the application of the first metal
14 coating to the polyimide base 28, and an annular portion
15 around the via 30 will be masked to prevent coating of
16 the base in this area surrounding where the grounded
17 solder ball 26 is desired.

18 On the circuit trace 34 side of the base 28, is a
19 circuit trace 36 which leads to a second via 38 which
20 connects the first metal coating constituting the ground
21 plane 22 to the second metal coating constituting the
22 circuit traces 34 through the polyimide base 28 at a
23 position removed from the via 30 at which the solder ball
24 26 is located. With this arrangement, the solder ball 26
25 remains free of direct contact with the ground plane 22,
26 but is maintained in electrical contact with the ground
27 plane 22 through the vias 30 and 38 and the circuit trace
28 36 connecting the two.

29 Since the solder ball 26 is free of direct contact
30 with the ground plane 22 by virtue of the fact that the
31 solder ball 26 is completely surrounded by an annular
32 area of the polyimide base 28, the solder ball 26 will
33 not wet the polyimide of the surrounding base 28 and so
34 will not flow along the ground plane 22 as described with
35 respect to the prior art of Figures 1 through 3. Thus
36 the solder ball 26 will maintain its shape even though
37 subjected to the temperatures required for mass reflow

1 attachment of the solder ball 26 to the flexible circuit
2 20.

3 Figure 7 illustrates an alternate embodiment of a
4 flexible circuit 40 which shows two ways the flexible
5 circuit 20 of Figures 4 through 6 could be changed and
6 still retain the function described above. The via 42
7 could be a "blind" via in that the two metal coatings 44
8 and 46 are in contact through the polyimide base 48 as
9 above, but there is no through-hole as previously
10 illustrated. Also, the via 50 to which the solder ball
11 52 is attached need not be provided with the first
12 surface coating as illustrated in the previous Figures.
13 As shown, the polyimide base 48 could simply be provided
14 with a through-hole 54 formed by such means as punching,
15 chemical etching or laser drilling which is large enough
16 to allow the solder ball 52 to contact the second coating
17 46 defining the circuit traces.

18 Thus there has been described a flexible circuit
19 construction which permits the mass reflow attachment of
20 solder balls to the ground plane of a double-sided
21 flexible circuit while preventing the collapse of the
22 solder ball and flow of the solder ball along the ground
23 plane. Although the invention has been described with
24 respect to only a limited number of embodiments, many
25 changes will be apparent to those skilled in the art.
26 For example, multiple solder balls may be connected to a
27 single distant via connecting the first conductive
28 surface and the second conductive surface. In addition,
29 the clear areas around the solder balls need not be
30 circular as shown but rather could be any shape so long
31 as the solder balls are free of contact with the first
32 conductive surface.

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PCT/US96/06292

1 The invention claimed is:

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3 1. A flexible circuit structure capable of mass
4 reflow attachment of solder balls to a ground plane
5 thereof, the flexible circuit structure comprising:

6 a flexible polymeric base having two major surfaces;
7 a first metal coating disposed on one major surface
8 of said base;

9 a second metal coating defining circuit traces on
10 the other major surface of said base;

11 a clear area on said first major surface free of
12 said first metal coating and sufficiently large so as to
13 accept a solder ball disposed therein without contact
14 between said first metal coating and said solder ball;

15 a hole in said clear area through said base and
16 communicating with said second metal coating;

17 a via connecting said first and said second metal
18 coatings through said base and removed from said clear
19 area;

20 a circuit trace of said second metal coating
21 extending from said hole to said via;

22 so that a solder ball placed in said hole may be
23 mass reflow attached to said second metal coating through
24 said hole while remaining free of direct physical contact
25 with said first metal surface, but while being in
26 electrical contact with said first metal coating through
27 said circuit trace extending from said hole to said via
28 and through said via.

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30 2. A flexible circuit structure according to claim
31 1 wherein said via is a through via in that a hole
32 extends through said first metal coating, said second
33 metal coating and said base at said via.

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35 3. A flexible circuit structure capable of mass
36 reflow attachment of solder balls to a ground plane
37 thereof, the flexible circuit structure comprising:

38 a flexible, polymeric base;

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1 a first conductive coating defining a ground plane
2 disposed on one side of said base;
3 a second conductive coating defining circuit traces
4 on the other side of said base;
5 a first via connecting said first conductive coating
6 and said second conductive coating;
7 a second via connecting said first conductive
8 coating and said second conductive coating, said second
9 via being removed from said first via;
10 an area completely surrounding said first via free
11 of said first conductive coating; and
12 a circuit trace defined by said second conductive
13 coating electrically connected to said first via and
14 leading to said second via;
15 so that a solder ball may be placed in said first
16 via on said first conductive coating of said flexible
17 circuit and mass reflow soldered to said first via while
18 remaining free of physical contact with said first
19 conductive surface surrounding said first via, but while
20 remaining in electrical contact with said first
21 conductive surface surrounding said first via through
22 said circuit trace and said second via.
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24 4. A flexible circuit structure according to claim
25 3 wherein said second via is a through via in that a
26 hole extends through said first conductive coating, said
27 second conductive coating and said base at said second
28 via.

