

FLEXIBLE RING INTERCONNECTION SYSTEM

Background Of The Invention

The present invention relates generally to high-density electrical interconnections structures and more particularly to such an interconnection structure that may be used in interposer applications and to connect electrical devices to circuit boards.

5 Microelectronic devices such as state-of-the-art microprocessors require large numbers of reliable connections in increasingly-small areas. As the number of connections between an electronic device and a substrate to which the device is to be mounted increases, the likelihood that just a single connections will not be made or will fail increases.

10 In "wave soldering," an electronic components is soldered to a substrate by flowing molten solder over a substrate in which electronic components are mounted. A substrate, to which electronic components are to be soldered, is passed over the flowing, molten solder such that exposed metal and fluxed surfaces on the lower surface of the substrate surface wick the molten solder upward from the solder bath. As the substrate with the wicked, molten solder moves away from the molten solder bath, the solder cools and solidifies, establishing an
15 electrical connection between electronic devices and soldered surfaces of the substrate.

As connection density increases in the electronic arts and lead lengths from electronic devices decreases, the increasing number of connections that must be made make it statistically more likely that even a single connection will not be made or will fail. Even minor irregularities in a substrate's planarity can cause connection problems.

20 One problem with prior art soldering techniques arises when the contact surfaces of a substrate and an electronic device are separated from each other by different distances. For example, if one or two contact leads or one or two contact surfaces of a microprocessor are more widely separated from a planar substrate than the other contact leads or contact surfaces, the molten solder might not wick between the substrate and the more-distant contact surfaces of the
25 electronic device. Prior art soldering techniques suffer from an inability to make a connection when the spacing or distance between contact surfaces of two devices or surfaces to be joined, varies by more than a small amount.

When even a single connection between an electronic device and its supporting substrate is either not made at the time of manufacture, or fails while in use, the cost to identify a failed

electrical connection and to repair it can often exceed the cost to manufacture the product in which the electronic device and supporting substrate operates. Improving the manufacturability of electrical connections and improving the reliability of electrical connections after manufacture would be an improvement over the prior art.

5 The present invention is directed to a connector structure that is suitable for use in high-density applications, is easy to manufacture and which provides a reliable contact force while avoiding the aforementioned shortcomings.

Summary Of The Invention

10 It is a general object of the present invention to provide a connector device that has a plurality of flexible, conductive rings arranged in an array so as to contact conductive pads on a circuit board and contacts or contact pads of an opposing electronic device.

15 Microelectronic devices are electrically connected and mounted to a circuit board or other planar surface using small conductive hollow rings between electrical contacts of an electronic device and a circuit board or substrate. Each ring is a band of pliant conductive material that extends around a center point. An axis of rotation extends through each ring. Each ring's axis of rotation is substantially parallel to the other axes of rotation and to the plane of the substrate and the plane of the electronic device.

20 Each ring acts as a small, round spring-type of contact which will deform when a force is directed toward the interior of the ring from any direction. When the force is removed, the ring will return to its original shape. The resilient behavior of the rings provide a small, flexible interconnection which can accommodate variations in the planarity of opposing surfaces. Each ring's flexibility also accommodates circuit board or substrate flexing as well as impacts and vibration.

25 These and other objects, features and advantages of the present invention will be clearly understood through a consideration of the following detailed description.

Brief Description Of The Drawings

In the course of this detailed description, the reference will be frequently made to the attached drawings in which:

30 FIG. 1 is a perspective view of a discrete conductive hollow ring constructed in accordance with the principles of the present invention, and which is suitable for connecting an

electronic device to a circuit board or other substrate;

FIG. 1A shows the deformation of the discrete conductive hollow ring of FIG. 1 in response to an externally-applied force;

FIG. 2 is a side elevation of a microelectronic device and a plurality of conductive hollow mounting rings mounted to a substrate;

FIG. 3 is a side elevation of a conductive mounting ring filled with a resilient, non-conductive material and the ring being soldered to a substrate;

FIG. 4 is a side elevation of a substrate and a plurality of conductive hollow mounting rings mounted to an electronic device; and,

FIG. 5 shows a conductive ring and the space between an electronic device and a substrate filled with non-conductive resilient material.

Detailed Description Of The Preferred Embodiments

FIG. 1 is a perspective view of a discrete conductive hollow ring 10 which is constructed in accordance with the principles of the present invention and which may be used for the mounting of an electronic device to a circuit board or other substrate. In the embodiment shown, the conductive hollow ring 10 has a diameter **D** substantially the same as the length **L** of the ring 10, but other configurations may be used .

The ring is preferably made up of a band of pliant conductive material, such as a copper or gold alloy or a spring steel coated or plated with a good conductor such as copper or gold. Alternate embodiments can include resilient plastics that are either plated or otherwise conductively coated. Regardless of its material, as is true of all rings, the material from which it is made is centered about a point in space 12 through which extends an axis of rotation 14 for the ring 10. A force, **F**, exerted on the ring 10 from the exterior, and directed radially inward of the ring, will cause the ring 10 to deflect as shown in FIG. 1A. As is well-known, as the force **F** increases past the material's elastic limit, the ring will collapse but as long as the applied force **F** remains below the elastic limit of the ring material, the ring 10 will act as a spring, and return to its original shape when the applied force is removed. The spring-like action of the ring 10, when used as in array of rings will provide a connection that can accommodate planarity differences between a substrate 8 and an electronic device 6. It can also provide a connection that can be flexed and which will be more tolerant of impact and vibration. The improved physical robustness is provided by the flexible material from which the ring 10 is made, a portion of

which between the substrate 8 and device 4 is not soldered. The rings may be easily by-electro forming or electro-discharge machining to maintain the tolerances down to critical sizes and diameters, such as 500 micrometers and the like.

The ring 10 illustrated is provided with two strips, or bands, of nickel-plating 20, 22 that run along the side of the ring 10 from one open end to the other. The nickel plating bands 20 and 22 act as and are referred to herein as solder barriers 20 and 22. As shown, they are substantially opposite to each other on the exterior surface of the ring 10. They prevent solder from wicking all the way up and around the circumference of the ring, thereby insuring that at least part of flexible ring side wall will not be soldered to the substrate 8 or an opposing surface, but rather will still remain pliant.

As shown in FIG. 3, when the ring 10 is attached to a substrate 8, molten solder will only wick upwardly until it reaches the solder barriers 20 and 22. Solder that wicks upward along the exterior of the ring 10 will form fillets 24 between the ring's 10 lower curvature (FIG. 10) and the top of the substrate 8 as part of the normal soldering process. The solder barriers 20 and 22 insure that flexible material from which the ring 10 is made will not be completely coated with solder during a soldering process, insuring that the ring 10 will retain flexibility.

In a preferred embodiment as shown in FIG. 1, the ring 10 side wall cross-section is substantially planar or rectangular. In an alternate embodiment, the ring side wall cross-section can be circular, oval or other shape although non-rectangular side wall shapes might tend to be more rigid. Inasmuch as a circle and an oval are both special case ellipses, the more general side wall shape is referred to herein as elliptical.

FIG. 2 is a side elevation of a microelectronic device 4 positioned just above a plurality of conductive hollow mounting rings 10, the assembly of which comprise a connector 2 for mounting the electronic device 4 to a circuit board or other substantially planar substrate 8. Each of the rings 10 in FIG. 2 is substantially the same as the ring 10 shown in FIG. 1 albeit in FIG. 2, the solder barriers 20 and 22 are not visible.

The mounting rings 10 in FIG. 2 are aligned to that each of their axes 14 are parallel to each other and extending into the plane of the figure. In an alternate embodiment, the rings 10 can have their axes co-linear.

Inasmuch as the axes 14 extend into the plane of FIG. 2, the axes 14 of the rings 10 also tend to extend parallel to the plane of the substrate 8 which also extends into the plane of FIG. 2, as well as the plane of the underside 6 of the device 4. The side walls of each ring therefore

“face” the substrate 8 and the underside 6 of the device 4. The planes in which the ring 10 open ends lie are substantially orthogonal to the substrate surface 8 and the underside 6 of the electronic device 4.

The several discrete conductive hollow rings 10 each provide a redundant signal path along its body between conductive traces on the surface 8 of the substrate and connection points or nodes on the under side 6 of the electronic device 4. Signals can traverse both sides of the ring to get from circuits on the device 4 to circuits on the substrate 8 below. This dual signal path also assist in reducing the inductance of the system in which such contacts are used. As shown in FIG. 2, the several conductive rings 10 are initially attached to the substrate 8 and provide a connector for the device 4.

FIG. 3 shows an alternate embodiment of a conductive ring 10 wherein the interior 18 of the ring 10 is filled with a resilient, non-conductive material 18, such as silicone. The aforementioned solder fillets 24 mechanically and electrically attached the ring 10 to the substrate 8. Filling the interior 18 space with a resilient material increases the strength of the ring 10 but also prevents solder from flowing into the interior space 18 by either wicking or capillary action.

FIG. 4 shows a connector 2 for mounting an electronic device. In FIG. 4, the connector 2 is formed using the aforementioned discrete conductive rings 10, but the connector 2 in FIG. 4 includes a non-conductive under fill material 26 which holds the conductive rings 10 in place with respect to each other. The under fill material 26 can be a non-conductive silicone layer, the thickness of which is less than the outside diameter of the conductive rings 10. When the electronic device 4 is urged downward, each of the rings will deform slightly. Because they are pliable, with each of them tending to oppose a downward compressive force, each conductive ring 10 will tend to make physical contact with the surface of the substrate 8 below it as well as the surface 6 of the electronic device 4 above it. Each ring will therefore provide a better electrical and physical contact than is otherwise possible with a straight pin used in the prior art.

FIG. 5 shows a non-conductive, resilient under fill material 26 disposed between the device 4 and a substrate. It also shows the hollow conductive ring 10 filled with the under fill material, adding stiffness to the ring 10.

The connector 2 shown in FIG. 4 can be initially attached to the substrate 8 or to the electronic device 4. It can be wave soldered to either the substrate 8, the device 4 or both of them simultaneously.

As shown in FIG. 2 and FIG. 3, each of the hollow contact rings 10 of the connector 2 shown in FIG. 4 has solder barriers (not shown in FIG 4) which prevent molten solder from wicking all the way around the ring 10 thereby defeating the flexibility provided by the thin metal from which the rings are made.

5 The hollow, conductive rings are preferably made from electronically conductive metals that will also accept a solder barrier. Copper, silver and gold are excellent conductors and can be alloyed with other metals that can provide good resilience; they can also be locally plated with solder-barrier metals such as nickel. The rings 10 can also be formed from metal-plated plastics.

10 Those of skill in the art will appreciate that since each of the rings 10 can be slightly compressed from its original shape that the rings can overcome slight variations in the planarity of the substrate 8 and/or the electronic device 4. By providing a solder barrier that prevents solder from wicking all the way around a ring, each ring's flexible side walls acts as a small round spring and will deform when a force is directed toward the interior of the ring. When the
15 force is removed, the ring will return to its original shape. The resilient behavior of the rings provide a small, flexible interconnection which can accommodate variations in the planarity of opposing surfaces. Each ring's flexibility also accommodates circuit board or substrate flexing as well as impacts and vibration. The resulting connection between the substrate 8 and an
20 electronic device 4 is more tolerant of substrate and/or device flexing. The connection is also less susceptible to shock or vibration-induced failure.

 While the preferred embodiment of the invention have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made therein without departing from the spirit of the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. A connector for mounting a microelectronic device having a planar mounting surface to a planar substrate, the connector comprising:
a plurality of discrete conductive hollow rings, each ring being a band of pliant conductive material around a corresponding center point for each ring, and through
5 which extends an axis of rotation for each ring, the band of pliant material enclosing a hollow volume, the axes of rotation of the rings being parallel to each other, parallel to the plane of the substrate and the plane of the connector.
2. The connector of claim 1, wherein each ring includes a rectangular cross-section.
3. The connector of claim 1, wherein each ring includes an elliptical cross-section.
4. The connector of claim 1, wherein the hollow volume of each said ring is filled with a resilient, non-conductive material.
5. The connector of claim 1, wherein each of said rings is provided with first and second solder barriers disposed on exterior surfaces of said ring.
6. The connector of claim 5, wherein said solder barriers are disposed opposite each other on the circumferences of said rings, the first and second solder barriers inhibiting the wicking of molten solder around the entire circumference of a ring.
7. A substrate for mounting a microelectronic device, comprising:
a planar substrate supporting conductive traces that are capable of carrying electrical signals;
a plurality of discrete conductive hollow rings, each of the rings being electrically
5 coupled to at least one conductive trace on the substrate, each said rings including a band of pliant conductive material extending around a corresponding center point for each said ring, and through which extends an axis of rotation for each said ring, the band of pliant material enclosing a hollow volume, said rings being arranged so that axes of rotation of said rings are disposed parallel to the plane of said substrate, said rings being located on

- 10 said planar substrate in a pattern so as to mate with contact surfaces of an electronic component.
8. The substrate of claim 7, wherein each ring is provided with first and second solder barriers on the surface of each ring that are located opposite each other on the circumference of each ring, the first and second solder barriers inhibiting the wicking of molten solder around the entire circumference of a ring.
9. An electronic device comprising:
 a planar connection surface having a plurality of electrical signal contact surfaces;
 an electrically conductive hollow contact ring that is electrically connected to each electrical contact surface, each ring being a band of pliant conductive material
5 around a corresponding center point for each ring, and through which extends an axis of rotation for each ring, the band of pliant material enclosing a hollow volume, the axes of rotation of the rings being parallel to each other and parallel to the planar connection surface, the plurality of discrete conductive hollow rings being located on the planar connection surface to mate with contact surfaces of a planar substrate.
10. The electronic device of claim 9, wherein each ring is provided with first and second solder barriers on the surface of each ring that are located opposite each other on the circumference of each ring, the first and second solder barriers inhibiting the wicking of molten solder around the entire circumference of a ring.
11. A spring contact for use connecting electrical circuits of two members together, comprising:
 a ring having a continuous body of conductive material, the ring having an internal hollow volume and an exterior surface that defines a circumference of the ring body, said ring body having two opposing top and bottom surfaces interconnected together by two intervening side surfaces, a portion of each of said side surfaces including a solder-resistant material disposed thereon.
12. The spring contact of claim 11, wherein said hollow volume is filled with a non-

conductive material.

13. The spring contact of claim 12, wherein said non-conductive material includes silicone.