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METHOD FOR THE FABRICATION OF ELECTRICAL CONTACTS

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FIELD OF THE INVENTION

This invention relates generally to the field of electrical contacts and more specifically to methods for the fabrication of electrical contacts.

BACKGROUND OF THE INVENTION

Existing electrical contact designs include interposers constructed from elastomeric material and interposers constructed from balls of wire. Both of these solutions have limitations inherent in their design. Current elastomeric materials are unable to sustain adequate contact spring force over time and temperature and have a small range of working heights. Interposers constructed from balls of wire are fragile, prone to unravel, often require costly inspection, and provide a limited amount of contact travel.

SUMMARY OF THE INVENTION

A method for the fabrication of electrical contacts using metal forming, masking, etching, and soldering techniques is presented. The method produces a plurality of specialized electrical contacts, capable of use in an interposer, or other device, including non-permanent or permanent electrical connections providing contact wipe, soft spring rates, durability, and significant amounts of travel.

Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an embodiment of a printed circuit board comprising a quantity of through-plated vias according to the present invention.

Figure 2 is a perspective view of an embodiment of a metal sheet comprising a quantity of domes according to the present invention.

Figure 3 is a perspective view of the metal sheet of Figure 2 after masking and etching of the sheet to create a quantity of electrical contacts according to the present invention.

Figure 4 is a perspective view of the structure created by soldering the metal sheet of Figure 3 to the printed circuit board of Figure 1 according to the present invention.

Figure 5 is a perspective view of the structure of Figure 4 after the connections between the individual electrical contacts have been etched away according to the present invention.

Figure 6 is a perspective view of the structure of Figure 5 after the electrical contacts have been plated according to the present invention.

Figure 7 is a flowchart of a method for the creation of electrical contacts according to the present invention.

Figure 8 is a flowchart of a method for the creation of an interposer comprising micro-spiders according to the present invention.

Figure 9 is a flowchart of a method for the creation of an interposer comprising micro-spiders and ball grid array (BGA) balls according to the present invention.

Figure 10 is a flowchart of a method for the creation of micro-spiders according to the present invention.

Figure 11 is a perspective view of an embodiment of a three-legged micro-spider according to the present invention.

Figure 12 is a perspective view of embodiment of a plurality of three-legged micro-spiders on a substrate according to the present invention.

Figure 13 is a cross-sectional view of an embodiment of the present invention illustrating micro-spiders constructed on a first side of a substrate and ball grid array (BGA) balls constructed on a second side of a substrate.

DETAILED DESCRIPTION

Figure 1 is a perspective view of an embodiment of a printed circuit board (PCB) comprising a quantity of through-plated vias **106**, according to the present invention. In an example embodiment of the present invention a printed circuit board substrate **100** is plated with copper on both sides of the substrate and the copper is etched leaving areas of copper **104**, surrounding each of the holes **102**, on opposite sides of the substrate from each other. While the areas of copper **104** in this embodiment are somewhat elliptical in shape, other shapes of the areas of copper **104** will work equally well within the scope of the present invention. For example, in some embodiments of the present invention, the area of copper **104** may be circular, square, rectangular, or other, more complex, shapes. While copper is a preferred metal, other example embodiments of the present invention may use other materials for the plating. The substrate **100** may comprise a wide variety of materials, with fiberglass as a common choice of material. Holes **102** are then drilled through the center of each area of copper **104**. The barrel of the holes are then through-plated to connect the corresponding areas of copper **104** on opposite sides of the substrate **100** thereby forming an array of through-plated vias **106**. This drilled and plated PCB may be created by any standard PCB manufacturing system, and will be as the substrate for a plurality of specialized electrical contacts referred herein to as micro-spider

contacts. A PCB with these micro-spider contacts may be used as an interposer in an electronic system.

Figure 2 is a perspective view of an embodiment of a metal sheet comprising a quantity of domes according to the present invention. A metal sheet **200** is processed such that it comprises a plurality of small domes **202**. The metal sheet **200** may be copper or other conductive metals as needed for any particular implementation of the present invention. The size of the domes **202** may also be varied as needed for any particular implementation of the present invention. In an example embodiment of the present invention, the domes **202** in the metal sheet **200** have a one-to-one correspondence with the through-plated holes **102** on the PCB substrate **100**, however other embodiments of the present invention need not maintain this one-to-one correspondence.

Figure 3 is a perspective view of the metal sheet of Figure 2 after masking and etching of the sheet **200** to create a quantity of micro-spiders, each on their own footing **304**, according to the present invention. After the metal sheet **200** has been masked and etched, micro-spiders **300**, footings **304**, and connectors **302** between individual footings **304** remain forming an etched metal sheet **310**. Note that while Figure 3 shows a regular array of micro-spiders **300**, there is no need for the plurality of micro-spiders **300** to form a regular array, instead they may be formed only in locations where needed and longer connectors **302** used to connect the plurality of micro-spiders **300**.

Figure 4 is a perspective view of an embodiment of the structure created by soldering the metal sheet of Figure 3 to the printed circuit board of Figure 1 according to the present invention. The etched metal sheet **310** is soldered to the PCB structure of Figure 1, thereby forming an array of plated-through vias **106** covered by a corresponding array of micro-spiders **300**. The solder may be silk-screened onto the array of through-plated vias **106** to cover just the exposed metal areas **104** where it is desired that the

micro-spiders **300** make electrical contact. At this point in the process the individual micro-spiders **300** are physically and electrically connected to the individual areas of metal plating **104** surrounding their corresponding via hole **102** in the PCB substrate **100**.

Figure 5 is a perspective view of the structure of Figure 4 after the connections between the individual micro-spiders have been etched away according to the present invention. At this point in the process, all of the micro-spiders **300** have been separated from each other physically and electrically by etching away all of the connectors **302** between the individual micro-spiders **300**. Note that in some implementations of the present invention, it may be desired to have a plurality of micro-spiders **300** physically and electrically connected to each other at the completion of the interposer. In that case, the masking and etching of the PCB substrate **100** and the thin metal sheet **200** may be designed to leave larger areas of metal **104** surrounding the PCB vias **102** such that a plurality of vias are electrically connected, and corresponding areas of the thin metal sheet **200** may be left un-etched for later soldering to the array of through-plated vias **106**. Such an alternate embodiment of the present invention may be useful for power supply connections that commonly require a large amount of current-carrying capability.

Figure 6 is a perspective view of the structure of Figure 5 after the micro-spiders have been plated according to the present invention. In an example embodiment of the present invention, the micro-spiders **300** may be plated with nickel and gold, improving their durability and conductivity, and thereby forming an array of plated micro-spiders **600**.

Figure 7 is a flowchart of a method for the creation of micro-spiders **300** according to the present invention. In a step **702**, a PCB substrate **100** is plated, etched, and drilled to produce a plurality of through-plated vias **106** in the substrate **100**. In a step **704**, a quantity of domes are created in a first metal sheet **200**. In an example

embodiment of the present invention, the first metal sheet **200** may be copper. In a step **706**, a first mask layer is created over the first metal sheet **200**. In a step **708**, the first metal sheet **200** is completely etched away in areas not protected by the mask, producing a quantity of micro-spiders **300**, footings **304**, and connectors **302**. In a step **710**, after the mask layer is cleaned off, the first metal sheet **200** comprising a quantity of micro-spiders **300** is soldered to the plurality of through-plated vias **106** in the substrate **100**. In a step **712**, a second mask layer is created over the first metal sheet **200**. In a step **714**, all of the areas of the first metal sheet **200** that are not protected by the second mask layer are completely removed by etching. In a preferred embodiment of the present invention, the connectors **302** are left unprotected by the second mask layer and removed in the etching step. In a step **716**, the quantity of micro-spiders **300** is metal plated.

Some methods of applying and patterning the first mask layer may have difficulties is creating an adequate mask layer over an irregular surface such as that resulting from step **704** (creating a quantity of domes in a metal sheet). Further, some photolithography systems may have difficulties in patterning a mask layer over an irregular surface, particularly with the sides of the domes. When using masking systems that are unable to create an adequate mask layer over an irregular surface, it may be necessary to perform the steps of the present invention in a different order than that shown in Figure 7. For these reasons, in some example embodiments of the present invention, it may be beneficial to perform the step **706** of creating a first mask layer over the first metal sheet before the step **704** of creating a quantity of domes in the first metal sheet.

Figure 8 is a flowchart of a method for the creation of an interposer comprising micro-spiders according to the present invention. The method for the creation of an interposer including micro-spiders shown in this example embodiment of the present

invention includes the steps of the method shown in Figure 7, with the addition of steps to preferably create an additional quantity of micro-spiders on the opposite side of the printed circuit board substrate. As explained in connection with Figure 7, in a step **716**, the quantity of micro-spiders **300** is metal plated. In a step **802**, a quantity of domes is created in a second metal sheet **200**. This step **802** may occur concurrently with step **702**, if desired. In a step **804**, a third mask layer is created over the second metal sheet **200**. This step **804** may occur concurrently with step **706**, if desired. In a step **806**, the second metal sheet **200** is completely etched away in areas not protected by the third mask, producing a quantity of micro-spiders **300**. This step **806** may occur concurrently with step **708**, if desired. In a step **808**, after the third mask layer is cleaned off, the second metal sheet **200** including a quantity of micro-spiders **300** is soldered to the plurality of through-plated vias **106**. This step **808** may occur concurrently with step **710**, if desired. In a step **810**, a fourth mask layer is created over the second metal sheet **200**. This step **810** may occur concurrently with step **712**, if desired. In a step **812**, all of the areas of the second metal sheet **200** that are not protected by the fourth mask layer are completely removed by etching. This step **812**, may occur concurrently with step **714**, if desired. In a step **814**, the second quantity of micro-spiders **300** is metal plated. This step **814**, may occur concurrently with step **716**, if desired. Once again, in some embodiments of the present invention, it may be desirable to create the mask layers over the thin metal sheets before forming the domes in the thin metal sheets. This example embodiment (Figure 8) of the present invention may be used to create a dual micro-spider interposer for use between a printed circuit board and a circuit module, such as an application-specific integrated circuit (ASIC) package, or a multi-chip module. The dual micro-spider interposer is easy to remove from the printed circuit board without costly rework of the

board. This allows for quick and easy changes of the circuit module, including changes in the field, if needed.

Figure 9 is a flowchart of a method for the creation of an interposer comprising micro-spiders and ball grid array (BGA) balls according to the present invention. The method for the creation of an interposer including micro-spiders and BGA balls shown in this example embodiment of the present invention includes the steps of the method shown in Figure 7, with the addition of steps to preferably create a quantity of BGA balls on the opposite side of the printed circuit board substrate. As explained in connection with Figure 7, in a step **716**, the quantity of micro-spiders **300** is metal plated. In a step **902**, ball grid array (BGA) balls are attached to the side of the substrate opposite from the micro-spiders. Once again, in some embodiments of the present invention, it may be desirable to create the mask layers over the thin metal sheets before forming the domes in the thin metal sheets. By creating an interposer comprising micro-spiders on one side and BGA balls on the other, thinner gold may be used on a printed circuit board that the BGA side of the interposer attaches to. This enables the use of standard BGA attachment processes to attach the interposer to the printed circuit board. While this implementation of the present invention (Figure 9) enables less expensive plating on the printed circuit board, the removeability of the dual micro-spider interposer (Figure 8) allows for easier re-work than the micro-spider BGA interposer.

Figure 10 is a flowchart of a method for the creation of micro-spiders in accordance with the present invention. In an example embodiment of the present invention similar to the method of Figure 7, a metal sheet is etched into a micro-spider configuration before the micro-spiders are domed. This method allows for masking and etching of the metal sheet before dome formation, eliminating the difficulties of masking and etching a domed surface. In a step **702**, a PCB substrate **100** is plated, etched, and

drilled to produce a plurality of through-plated vias **106**. In a step **706**, a first mask layer is created over a first metal sheet **200**. In a step **708**, the first metal sheet **200** is completely etched away in areas not protected by the mask, producing a quantity of micro-spiders **300**, footings **304**, and connectors **302**. In a step **1000**, a substantially incompressible material is deposited between the legs of the micro-spiders etched into the metal sheet. The substantially incompressible material is used to keep the legs of the micro spider from improperly bending during the step **704** of forming domes. It may comprise a material such as plaster of paris, and one example embodiment of the present invention uses a silk-screening process for applying the material. Next, in a step **704**, a quantity of domes are created in the first metal sheet **200**. In a step **1002**, the substantially incompressible material is removed from between the legs of the micro-spiders. Depending on the material used, the substantially incompressible material may be removed by dissolution or other equivalent processes. In a step **710**, after the mask layer is cleaned off, the first metal sheet **200** including a quantity of micro-spiders **300** is soldered to the plurality of through-plated vias **106**. In a step **712**, a second mask layer is created over the first metal sheet **200**. In a step **714**, all of the areas of the first metal sheet **200** that are not protected by the second mask layer are completely removed by etching. In a step **716**, the quantity of micro-spiders **300** is metal plated.

Figure 11 is a perspective view of an embodiment of a three-legged micro-spider according to the present invention. A three-legged micro-spider 1100 is shown connected to the area of metal **104** surrounding a through-plated hole **102** in a substrate **100**.

Figure 12 is a perspective view of a plurality of an embodiment of three-legged micro-spiders **1100** on a substrate **100** in accordance with the present invention. While this figure shows a regular array of micro-spiders **1100**, other embodiments of the present invention may use an irregular array of micro-spiders **1100** as desired by the intended use

of the plurality of micro-spiders **1100**. Further, micro-spiders may be constructed with any number of legs (greater than one) as desired by an intended use, within the scope of the present invention.

In a specific example embodiment of the present invention, micro-spiders **300** are preferably constructed on a first side of the substrate **100** and ball grid array balls **1000** are preferably constructed on a second side of the substrate **100**, creating an interposer for use in non-permanently attaching electronic devices such as a multi-chip module (MCM) to a circuit board. Figure 13 is a cross-sectional view of such an embodiment. The example embodiment of the present invention shown in Figure 13 illustrates a plurality of micro-spiders **300** constructed on a first side of a substrate and ball grid array (BGA) balls **1300** constructed on a second side of a substrate **100**, connected together by through-plated holes **102** surrounded by areas of metal **104** contacting the micro-spiders **300**. This example embodiment of the present invention may be employed as an interposer for use in non-permanently attaching electronic devices such as a MCM to a circuit board, while the interposer is attached to the circuit board by the BGA balls **1300**. The example embodiment of the present invention may be fabricated using the process described in connection with Figure 9.

The resulting micro-spiders are described further in a U.S. patent application, Serial No. _____, "Electrical Contact", filed concurrently with the present application, and incorporated herein by reference. Another method for the fabrication of micro-spiders is described further in a U.S. patent application, Serial No. _____, "Method for the Fabrication of Electrical Contacts", filed concurrently with the present application, and incorporated herein by reference.

What is claimed is:

1. A method for the fabrication of electrical contacts comprising the steps of:

a) through-plating a plurality of a plurality of vias in a substrate;

b) forming a plurality of domes in a first metal sheet;

c) placing a first mask layer on said first metal sheet;

d) first etching said first metal sheet in all areas not protected by said first mask layer thereby producing a plurality of electrical contacts, wherein said electrical contacts include spiraling legs configured to create a wiping action on metal pads;

e) soldering said etched first metal sheet to said plurality of through-plated vias;

f) placing a second mask layer on said etched first metal sheet; and

g) second etching said etched first metal sheet in all areas not protected by said second mask layer resulting in the physical and electrical separation of at least some of said plurality of electrical contacts.

2. The method for the fabrication of electrical contacts of claim 1, wherein said substrate includes metal areas surrounding substantially all locations of said vias before said vias are created in said substrate.

3. The method for the fabrication of electrical contacts of claim 1, further comprising the step of:

h) plating said second etched first metal sheet.

4. The method for the fabrication of electrical contacts of claim 3, wherein said plating uses gold.

5. The method for the fabrication of electrical contacts of claim 3, wherein said plating uses nickel and gold.

6. The method for the fabrication of electrical contacts of claim 1, further comprising the step of:

h) removing said first mask layer after said first etching is complete.

7. The method for the fabrication of electrical contacts of claim 1, further comprising the step of:

h) removing said second mask layer after said second etching is complete.

8. The method for the fabrication of electrical contacts of claim 1, wherein said metal sheet is copper.

9. The method for the fabrication of electrical contacts of claim 1, wherein said second etching step separates less than all of said plurality of electrical contacts.

10. The method for the fabrication of electrical contacts of claim 1, wherein said substrate is a printed circuit board substrate.

11. The method for the fabrication of electrical contacts of claim 1, further comprising the steps of:

h) forming a plurality of domes in a second metal sheet;

i) placing a third mask layer on said second metal sheet;

j) first etching said second metal sheet in all areas not protected by said third mask layer thereby producing a plurality of electrical contacts, wherein said electrical contacts include spiraling legs configured to create a wiping action on metal pads;

k) soldering said etched second metal sheet to said plurality of through-plated vias on opposing side of said substrate from said etched first metal sheet;

l) placing a fourth mask layer on said etched second metal sheet; and

m) second etching said etched second metal sheet in all areas not protected by said fourth mask layer resulting in the physical and electrical separation of at least some of said plurality of electrical contacts.

12. The method for the fabrication of electrical contacts of claim 11, wherein said second etching of said etched first metal sheet and said second etching of said etched second metal sheet occur at least partially concurrently.

13. The method for the fabrication of electrical contacts of claim 1, further comprising the steps of:

h) adding a plurality of ball grid array balls to said through-plated vias on a side of said substrate opposite from said plurality of electrical contacts.