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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 substrate including an array of holes according to the present invention.

Figure 2 is a close-up perspective view of an embodiment of one of the substrate holes from Figure 1 according to the present invention.

Figure 3 is a perspective view of an embodiment of the structure of Figure 2 after through plating and etching according to the present invention.

Figure 4 is a perspective view of an embodiment of the structure of Figure 3 with the addition of a molded dome according to the present invention.

Figure 5 is a perspective view of an embodiment of the structure of Figure 4 after the dome has been metal plated according to the present invention.

Figure 6 is a perspective view of an embodiment of the structure of Figure 5 after the addition of a mask layer according to the present invention.

Figure 7 is a perspective view of an embodiment of the structure of Figure 6 after the metal layer has been etched away in all areas not covered by the mask layer according to the present invention.

Figure 8 is a perspective view of an embodiment of the structure of Figure 7 after the mask layer has been removed according to the present invention.

Figure 9 is a perspective view of an embodiment of the structure of Figure 8 after the dome has been dissolved according to the present invention.

Figure 10 is a top view of an embodiment of the final micro-spider contact structure from Figure 9 according to the present invention.

Figure 11 is a perspective view of an embodiment of an array of clockwise micro-spiders according to the present invention.

Figure 12 is a cross-section view of an embodiment of a micro-spider interposer according to the present invention.

Figures 13A and 13B are cross-section views of embodiments of single micro-spider interposer pairs according to the present invention.

Figure 14 is a view of an embodiment of a single clockwise micro-spider and a single micro stop according to the present invention.

Figure 15 is a cross-section view of an embodiment of the structure from Figure 14 according to the present invention.

Figure 16 is a flowchart of a method of creating micro-spider contacts according to the present invention.

Figure 17 is a perspective view of an embodiment of a three-legged micro-spider.

Figure 18 is a perspective view of an embodiment of a plurality of three-legged micro-spiders on a substrate according to the present invention.

Figure 19 is a cross-section view of an embodiment of a micro-spider/ball grid array interposer according to the present invention.

DETAILED DESCRIPTION

Figure 1 is a perspective view of an embodiment of a substrate including an array of holes according to the present invention. A quantity of holes or vias **102** is created in a substrate **100**. In an example embodiment of the present invention the holes may be drilled into a printed circuit board (PCB) substrate. In an example embodiment of the present invention using a PCB substrate, metal pads may be placed on the substrate surrounding the planned locations of the holes before the holes are drilled. Other methods of creating the holes, such as etching, and other substrate materials, such as ceramics, may be used within the scope of the present invention. The quantity of holes

102 does not need to form a regular array shown in Figure 1. In other embodiments of the present invention, the holes may be irregularly spaced as desired for any particular design. The PCB substrate material is commonly fiberglass, however other materials may be used within the scope of the present invention.

Figure 2 is a close-up perspective view of an embodiment of one of the substrate holes from Figure 1 according to the present invention. A hole **102** in a substrate **100** is shown here.

Figure 3 is a perspective view of an embodiment of the structure of Figure 2 after through-plating and etching according to the present invention. After through-plating, the hole **102** has a ring of metal plating **300** surrounding the hole **102** and through the hole **102** to the opposite side of the substrate **100**. While the areas of metal plating **300** in this embodiment are circular in shape, other shapes of the areas of metal **300** will work equally well within the scope of the present invention. For example, in some embodiments of the present invention, the area of metal **300** may be elliptical, square, rectangular, or other, more complex shapes. While copper is a preferred metal for the metal plating, other example embodiments of the present invention may use other materials for the plating.

Figure 4 is a perspective view of an embodiment of the structure of Figure 3 with the addition of a molded dome according to the present invention. A molded dome **400** is added to at least some of the through-plated holes **102**. Molded domes **400** may be added to none, some, or all of the through-plated holes **102** on each side of the substrate **100**. In an example embodiment of the present invention, molded domes **400** are added to both sides of the substrate **100** to create a dual micro-spider interposer. A specialized electrical contact created pursuant to the present invention is referred herein to as a micro-spider contact, or simply as a micro-spider. In an alternate embodiment of the present

invention, molded domes **400** are added to only one side of the substrate **100** to create a micro-spider/ball grid array (BGA) ball interposer.

Figure 5 is a perspective view of an embodiment of the structure of Figure 4 after the dome has been metal plated according to the present invention. The metal plated dome **500** of Figure 5 may include copper or other metal elements or compositions according to design requirements.

Figure 6 is a perspective view of an embodiment of the structure of Figure 5 after the addition of a mask layer according to the present invention. A mask layer **600** in the shape of a clockwise micro-spider has now been added over the metal plated dome **500**. The mask layer may comprise photoresist and be applied by any number of methods. The photoresist may be exposed and developed to produce the mask layer **600** in the shape of micro-spiders.

Figure 7 is a perspective view of an embodiment of the structure of Figure 6 after the metal layer has been etched away in all areas not covered by the mask layer according to the present invention. An etched micro-spider **700**, covered with the mask layer **600**, is seen in place over the molded dome **400** on the substrate **100**.

Figure 8 is a perspective view of an embodiment of the structure of Figure 7 after the mask layer **600** has been removed from the micro-spider **700**.

Figure 9 is a perspective view of an embodiment of the structure of Figure 8 after the dome has been dissolved according to the present invention. The molded dome **400** may be preferably dissolved by any chemicals (or other etching method) capable of completely removing the dome material without damaging the micro-spider **700**, plating **300**, hole **102**, or substrate **100**.

Figure 10 is a top view of an embodiment of the micro-spider contact structure from Figure 9 according to the present invention. A single clockwise micro-

spider **700** is shown over a through-hole **102** surrounded by metal plating **300** on a substrate **100**. At this point the micro-spider may undergo further processing such as additional metal plating if desired. Also note that in other embodiments of the present invention counter-clockwise micro-spiders may be produced as desired. For example, it may be advantageous to design a large array of micro-spiders such that substantially equal numbers of clockwise and counter-clockwise micro-spiders are created. Such a design may reduce the rotational torque that would occur in an array of only clockwise or only counter-clockwise micro-spiders. Since the micro-spiders each rotate slightly, creating a wiping action on the contact during use, each micro-spider causes a small amount of torque on the device as it is connected.

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.

Figure 11 is a perspective view of an embodiment of an array of clockwise micro-spiders **700** shown over a substrate **100** according to the present invention. As disclosed above, in some embodiments of the present invention, it may be desired to alternate clockwise and counter-clockwise micro-spiders, for example in a checkerboard pattern.

Figure 12 is a cross-section view of an embodiment of a micro-spider interposer according to the present invention. In this example embodiment of the present invention micro-spiders are constructed on both sides of the substrate **100**. Connecting each pair of micro-spiders **700** is a through-plated hole **102**. The metal **300** surrounding each hole may be seen connecting to individual micro-spiders. While this example embodiment

comprises clockwise micro-spiders **700** on the top of the substrate **100**, and counter-clockwise micro-spiders **700** on the bottom of the substrate **100** other configurations are possible within the scope of the present invention.

Figures 13A and 13B are cross-section views of embodiments of single micro-spider interposer pairs according to the present invention. In Figure 13A a counter-clockwise micro-spider **700** is shown on the top of the substrate **100**, and a clockwise micro-spider **700** is shown on the bottom of the substrate **100**. The pair of micro-spiders **700** are electrically connected by a through-plated hole **102** and the metal **300** surrounding the hole. In Figure 13B a clockwise micro-spider **700** is shown on the top of the substrate **100**, and a counter-clockwise micro-spider **700** is shown on the bottom of the substrate **100**. The pair of micro-spiders **700** are electrically connected by a through-plated hole **102** and the metal **300** surrounding the hole.

Figure 14 is a perspective view of an embodiment of a single clockwise micro-spider **700** electrically connected to the metal **300** surrounding a hole **102** in the substrate **100** next to a micro stop **1400** in accordance to the present invention. The micro stop **1400** may be constructed using processes similar to standard printed circuit board processes, to create an elevated stop configured to prevent over-compression of the micro-spiders **700** during use. The height of the micro stop **1400** preferably enables compression and contact wiping action of the micro-spiders **700** while preventing over-compression that would physically damage the micro-spiders **700**.

Figure 15 is a cross-section view of an embodiment of the structure from Figure 14 according to the present invention. In this example embodiment of the present invention a micro-spider interposer including a pair of micro stops **1400** is shown in cross-section view. The clockwise micro-spider **700** on top of the substrate **100** is electrically connected to the counter-clockwise micro-spider **700** on the bottom of the

substrate through the metal **300** surrounding the through-plated hole **102** in the substrate **100**.

Figure 16 is a flowchart of a method of creating micro-spider contacts according to the present invention. In a step **1602**, a plurality of holes **102** are created in a substrate **100**. In a step **1604**, the holes **102** are through-plated and etched. In a step **1606**, molded domes are created over the through-plated holes **102**. In a step **1608**, the substrate **100** with the holes **102** covered by molded domes is metal-plated. In a step **1610**, a mask layer in the configuration of micro-spiders is created over the metal-plated domes. In a step **1612**, the metal-plating is etched away in all the places not covered by the mask layer. In a step **1614**, the mask layer is removed. In a step **1616**, the domes are dissolved or etched away leaving the finished micro-spiders. If desired, the micro-spiders may be metal-plated again with one or more additional metals, such as nickel or gold, at this point in the process. In an optional step **1618**, ball grid array (BGA) balls are placed on the through-plated holes **102** on a side of the substrate **100** opposite to the micro-spiders **700**. In such an embodiment of the present invention, micro-spiders **700** are placed on one side of the substrate **100** and BGA balls **1900** are placed on the other side of the substrate **100** producing a micro-spider/BGA interposer.

Figure 17 is a perspective view of an embodiment of a three-legged micro-spider according to the present invention. A three-legged micro-spider **1700** is shown connected to the metal **300** surrounding a through-plated hole **102** in a substrate **100**. 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.

Figure 18 is a perspective view of an embodiment of a plurality of three-legged micro-spiders on a substrate according to the present invention. Figure 18 shows an array of three-legged micro-spiders **1700** on a substrate **100**. While this figure shows a regular

array of micro-spiders **1700**, other embodiments of the present invention may use an irregular array of micro-spiders **1700** as desired by the intended use of the plurality of micro-spiders **1700**.

In a specific example embodiment of the present invention, micro-spiders **700** are preferably constructed on a first side of the substrate **100** and ball grid array balls **1900** 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 19 is a cross-sectional view of such an embodiment. The example embodiment of the present invention shown in Figure 19 illustrates a plurality of micro-spiders **700** constructed on a first side of a substrate and ball grid array (BGA) balls **1900** placed 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 **1900**. This example embodiment of the present invention may be fabricated using the process described in connection with Figure 16 including optional step **1618**.

What is claimed is:

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

a) through-plating a plurality of vias **102** in a substrate **100**;

b) creating domes **400** over at least some of said through-plated vias **102**;

c) first metal plating said domes **400**;

d) masking said domes **400**;

e) etching away said first metal plating on said domes **400** in areas not covered by said mask creating a plurality of electrical contacts **700**, wherein said electrical contacts **700** include spiraling legs configured to create a wiping action on metal pads when compressed; and

f) dissolving said domes **400**.

2. The method for the fabrication of electrical contacts of claim 1, wherein said substrate includes metal pads **300** surrounding substantially all locations of said vias **102** before said vias **102** are created in said substrate **100**.

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

g) second metal plating said electrical contacts **700** after said step of first metal plating.

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

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

6. The method for the fabrication of electrical contacts of claim 1, wherein said first metal plating is copper.

7. The method for the fabrication of electrical contacts of claim 1, wherein said substrate **100** is a printed circuit board substrate **100**.

8. The method for the fabrication of electrical contacts of claim 1, wherein at least some of said electrical contacts **700** are on opposite sides of said substrate **100**.

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

g) adding a plurality of ball grid array balls **1900** to said through-plated holes **102** on a side of said substrate **100** opposite to said electrical contacts **700**.

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

i) forming at least one micro stop **1400** on said substrate **100**.