

PACKAGING AND INTERCONNECTION OF CONTACT STRUCTURE**Field of the Invention**

This invention relates to an electronic packaging and interconnection of a contact structure, and more particularly, to an electronic packaging and interconnection for mounting a contact structure on a probe card or equivalent thereof which is used to test semiconductor wafers, semiconductor chips, packaged semiconductor devices or printed circuit boards and the like with increased accuracy, density and speed.

Background of the Invention

In testing high density and high speed electrical devices such as LSI and VLSI circuits, high performance probe contactors or test contactors must be used. The electronic packaging and interconnection of a contact structure of the present invention is not limited to the application of testing and burn-in of semiconductor wafers and die, but is inclusive of testing and burn-in of packaged semiconductor devices, printed circuit boards and the like. However, for the convenience of explanation, the present invention is described mainly with reference to a probe card to be used in semiconductor wafer testing.

In the case where semiconductor devices to be tested are in the form of a semiconductor wafer, a semiconductor test system such as an IC tester is usually connected to a substrate handler, such as an automatic wafer prober, to automatically test the semiconductor wafer. Such an example is shown in Figure 1 in which a semiconductor test system has a test head 100 which is ordinarily in a separate housing and electrically connected to the test system with a bundle of cables. The test head 100 and the substrate handler 400 are mechanically connected with one another with the help of a manipulator 500 driven by a motor 510. The semiconductor wafers to be tested are automatically provided to a test

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position of the test head by the substrate handler.

On the test head, the semiconductor wafer to be tested is provided with test signals generated by the semiconductor test system. The resultant output signals from the semiconductor wafer under test are transmitted to the semiconductor test system wherein they are compared with expected data to determine whether IC circuits on the semiconductor wafer function correctly.

The test head and the substrate handler are connected with an interface component 140 consisting of a performance board 120 which is a printed circuit board having electric circuit connections unique to a test head's electrical footprint, coaxial cables, pogo-pins and connectors. The test head 100 includes a large number of printed circuit boards 150 which correspond to the number of test channels. Each of the printed circuit boards has a connector 160 to receive a corresponding contact terminal 121 of the performance board 120. A "frog" ring 130 is mounted on the performance board 120 to accurately determine the contact position relative to the substrate handler 400. The frog ring 130 has a large number of contact pins 141, such as ZIF connectors or pogo-pins, connected to contact terminals 121, through coaxial cables 124.

Figure 2 shows, in more detail, a structure of the substrate handler 400, the test head 100 and the interface component 140 when testing a semiconductor wafer. As shown in Figure 2, the test head 100 is placed over the substrate handler 400 and mechanically and electrically connected to the substrate handler through the interface component 140. In the substrate handler 400, a semiconductor wafer 300 to be tested is mounted on a chuck 180. A probe card 170 is provided above the semiconductor wafer 300 to be tested. The probe card 170 has a large number of probe contactors (such as cantilevers or needles) 190 to contact with circuit terminals or contact targets in the IC circuit of the wafer

300 under test.

Electrical terminals or contact receptacles of the probe card 170 are electrically connected to the contact pins 141 provided on the frog ring 130. The contact pins 141 are also connected to the contact terminals 121 of the performance board 120 with coaxial cables 124 where each contact terminal 121 is connected to the printed circuit board 150 of the test head 100. Further, the printed circuit boards 150 are connected to the semiconductor test system through the cable 110 having several hundreds of inner cables.

Under this arrangement, the probe contactors 190 contact the surface of the semiconductor wafer 300 on the chuck 180 to apply test signals to the semiconductor wafer 300 and receive the resultant output signals from the wafer 300. The resultant output signals from the semiconductor wafer 300 under test are compared with the expected data generated by the semiconductor test system to determine whether the semiconductor wafer 300 performs properly.

Figure 3 is a bottom view of the probe card 170 of Figure 2. In this example, the probe card 170 has an epoxy ring on which a plurality of probe contactors 190 called needles or cantilevers are mounted. When the chuck 180 mounting the semiconductor wafer 300 moves upward in Figure 2, the tips of the cantilevers 190 contact the pads or bumps on the wafer 300. The ends of the cantilevers 190 are connected to wires 194 which are further connected to transmission lines (not shown) formed in the probe card 170. The transmission lines are connected to a plurality of electrodes 197 which contact the pogo pins 141 of Figure 2.

Typically, the probe card 170 is structured by a multi-layer of polyimide substrates having ground planes, power planes, signal transmission lines on many layers. As is well known in the art, each of the signal transmission lines is designed to have a characteristic impedance such as 50 ohms by balancing the distributed parameters, i.e., dielectric

constant of the polyimide, inductances, and capacitances of the signal within the probe card 170. Thus, the signal lines are impedance matched lines to achieve a high frequency transmission bandwidth to the wafer 300 providing current during steady state and high current peaks generated by the device's outputs switching. For removing noise, capacitors 193 and 195 are provided on the probe card between the power and ground planes.

An equivalent circuit of the probe card 170 is shown in Figure 4 to explain the limitation of bandwidth in the conventional probe card technology. As shown in Figures 4A and 4B, the signal transmission line on the probe card 170 extends from the electrode 197, the strip (impedance matched) line 196, the wire 194 and the needle (cantilever) 190. Since the wire 194 and needle 190 are not impedance matched, these portions function as an inductor L in the high frequency band as shown in Figure 4C. Because of the overall length of the wire 194 and needle 190 is around 20-30mm, the significant frequency limitation is resulted in testing a high frequency performance of a device under test.

Other factors which limit the frequency bandwidth in the probe card 170 reside in the power and ground needles shown in Figures 4D and 4E. If the power line can provide large enough currents to the device under test, it will not seriously limit the operational bandwidth in testing the device. However, because the series connected wire 194 and needle 190 for supplying the power (Figure 4D) as well as the series connected wire 194 and needle 190 for grounding the power and signals (Figure 4E) are equivalent to inductors, the high speed current flow is seriously restricted.

Moreover, the capacitors 193 and 195 are provided between the power line and the ground line to secure a proper performance of the device under test by filtering out the noise or surge pulses on the power lines. The capacitors 193 have a relatively large value such as $10\mu\text{F}$ and can be

disconnected from the power lines by switches if necessary. The capacitors 195 have a relatively small capacitance value such as $0.01\mu\text{F}$ and fixedly connected close to the DUT. These capacitors serve the function as high frequency decoupling on the power lines.

Accordingly, the most widely used probe contactors as noted above are limited to the frequency bandwidth of approximately 200MHz which is insufficient to test recent semiconductor devices. It is considered, in the industry, that the frequency bandwidth be of at least that equal to the tester's capability which is currently on the order of 1GHz or higher, will be necessary in the near future. Further, it is desired in the industry that a probe card is capable of handling a large number of semiconductor devices, especially memories, such as 32 or more, in parallel (parallel test) to increase test throughput.

To meet the next generation test requirements noted above, the inventors of this application has provided a new concept of contact structure in the U.S. Application No. 09/099,614 "Probe Contactor Formed by Photolithography Process" filed June 19, 1998. The contact structure is formed on a silicon or dielectric substrate through a photolithography process. Figures 5 and 6 show the contact structure in the above noted application. In Figure 5, all of the contact structures 30 are formed on a silicon substrate 20 through the same photolithography process. When the semiconductor wafer 300 under test moves upward, the contact structures 30 contact corresponding contact targets (electrodes or pads) 320 on the wafer 300.

The contact structure 30 on the silicon substrate 20 can be directly mounted on a probe card such as shown in Figure 3, or molded in a package, such as a traditional IC package having leads, so that the package is mounted on a probe card. However, packaging and interconnection of the contact structure 30 with respect to the probe card or equivalent

thereof is not described in the patent application.

Summary of the Invention

Therefore, it is an object of the present invention to provide a packaging and interconnection of a contact structure with respect to a probe card or equivalent thereof to be used in testing a semiconductor wafer, packaged LSI and the like.

It is another object of the present invention to provide a packaging and interconnection of a contact structure with respect to a probe card or equivalent thereof to achieve a high speed and frequency operation in testing a semiconductor wafer, packaged LSI and the like.

It is a further object of the present invention to provide a packaging and interconnection of a contact structure with respect to a probe card or equivalent thereof wherein the packaging and interconnection is formed at an edge of the contact structure.

It is a further object of the present invention to provide a packaging and interconnection of a contact structure which is formed between a contact trace provided at an edge of the contact structure and an interconnect pad of a printed circuit board.

It is a further object of the present invention to provide a packaging and interconnection of a contact structure which is formed between a contact trace provided at an edge of the contact structure and a connector.

It is a further object of the present invention to provide a packaging and interconnection of a contact structure which is formed between a contact trace provided at an edge of the contact structure and an interconnect pad of a printed circuit board through a solder bump.

It is a further object of the present invention to provide a packaging and interconnection of a contact structure which is formed between a contact trace provided at an edge of the contact structure and an interconnect pad of

a printed circuit board through a conductive polymer.

In the present invention, an electronic packaging and interconnection of a contact structure to be used in a probe card or equivalent thereof to test semiconductor wafers, semiconductor chips, packaged semiconductor devices or printed circuit boards and the like is established between a contact trace formed at an edge of the contact structure and various types of connection means on the probe card.

In one aspect of the present invention, a packaging and interconnection of a contact structure is comprised of: a contact structure made of conductive material and formed on a contact substrate through a photolithography process wherein the contact structure has a base portion vertically formed on the contact substrate, a horizontal portion, one end of which being formed on the base portion, and a contact portion vertically formed on another end of the horizontal portion; a contact trace formed on the contact substrate and electrically connected to the contact structure at one end, and the other end of the contact trace is extended toward an edge of the contact substrate; a printed circuit board (PCB) pad provided on a printed circuit board (PCB) substrate to be electrically connected with the other end of the contact trace; an elastomer provided under the contact substrate for allowing flexibility in the interconnection and packaging of the contact structure; and a support structure provided between the elastomer and the PCB substrate for supporting the contact structure, the contact substrate and the elastomer.

In another aspect of the present invention, a connector is provided to receive the other end of the contact trace to establish electrical connection therebetween. In a further aspect of the present invention, a conductive bump is provided between the other end of the contact trace and the PCB pad to establish electrical connection therebetween. In a further aspect of the present invention, a conductive

polymer is provided between the other end of the contact trace and the PCB pad to establish electrical connection thereamong.

According to the present invention, the packaging and interconnection has a very high frequency bandwidth to meet the test requirements in the next generation semiconductor technology. The packaging and interconnection is able to mount the contact structure on a probe card or equivalent thereof by electrically connecting therewith through the edge of the contact structure. Moreover, because of a relatively small number of overall components to be assembled, the interconnection and packaging of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Brief Description of the Drawings

Figure 1 is a schematic diagram showing a structural relationship between a substrate handler and a semiconductor test system having a test head.

Figure 2 is a schematic diagram showing an example of detailed structure for connecting the test head of the semiconductor test system to the substrate handler.

Figure 3 is a bottom view showing an example of the probe card having an epoxy ring for mounting a plurality of cantilevers as probe contactors.

Figures 4A-4E are circuit diagrams showing equivalent circuits of the probe card of Figure 3.

Figure 5 is a schematic diagram showing contact structures associated with the present invention produced through a photolithography process.

Figures 6A-6C are schematic diagrams showing examples of contact structure associated with the present invention formed on a silicon substrate.

Figure 7 is a schematic diagram showing a first embodiment of the present invention in which the packaging and interconnection is formed between a contact trace

provided at an edge of the contact structure and an interconnect pad of a printed circuit board.

Figure 8 is a schematic diagram showing a modified structure of the first embodiment of the present invention.

Figure 9 is a schematic diagram showing another modified structure of the first embodiment of the present invention.

Figure 10 is a schematic diagram showing a further modified structure of the first embodiment of the present invention.

Figure 11 is a schematic diagram showing a second embodiment of the present invention in which the packaging and interconnection is formed between a contact trace provided at an edge of the contact structure and a connector.

Figure 12 is a schematic diagram showing a modified structure of the second embodiment of the present invention.

Figure 13 is a schematic diagram showing a third embodiment of the present invention in which the packaging and interconnection is formed between a contact trace provided at an edge of the contact structure and an interconnect pad of a printed circuit board by means of a conductive bump.

Figure 14 is a schematic diagram showing a modified structure of the third embodiment of the present invention.

Figure 15 is a schematic diagram showing another modified structure of the third embodiment of the present invention.

Figure 16 is a schematic diagram showing a further modified structure of the third embodiment of the present invention.

Figure 17 is a schematic diagram showing a fourth embodiment of the present invention in which the packaging and interconnection is formed between a contact trace provided at an edge of the contact structure and an interconnect pad of a printed circuit board by means of a conductive polymer.

Figure 18 is a schematic diagram showing a modified structure of the fourth embodiment of the present invention.

Figure 19 is a schematic diagram showing another modified structure of the fourth embodiment of the present invention.

Figure 20 is a schematic diagram showing a further modified structure of the fourth embodiment of the present invention.

Detailed Description of the Preferred Embodiment

To establish a packaging and interconnection of a contact structure directly with a probe card or indirectly with a probe card through an IC package, examples of Figures 6A-6C show basic three types of electrical path extended from the contact structure to form such interconnections. Figure 6A shows an example in which such an electrical connection is established at the top of the substrate. Figure 6B shows an example in which an electrical connection is established at the bottom of the substrate while Figure 6C shows an example in which an electrical connection is formed at the edge of the substrate. Almost any types of existing IC package design or probe card design can accommodate at least one of the interconnect types of Figures 6A-6C.

Each of Figures 6A-6C include a contact interconnect trace 32 also designated by a which is to establish electrical connection with a probe card or any intermediate member to a probe card. The contact structure 30 has vertical portions b and d and a horizontal beam c and a tip portion e. The tip portion e of the contact structure 30 is preferably sharpened to achieve a scrubbing effect when pressed against contact targets 320 such as shown in Figure 3. The spring force of the horizontal beam c provides an appropriate contact force against the contact target 320. The inventors of this application have provided a detailed description of production process of the contact structure 30 and the contact interconnect trace 32 on the silicon

substrate 20 in the above noted U.S. Application No. 09/099,614.

In the present invention, the packaging and interconnection of a contact structure is directed to the type of structure having a contact trace at an edge (edge type contact trace) thereof as shown in Figure 6C. Various embodiments of the present invention on the edge type packaging and interconnection will be described with reference to the drawings.

Figures 7-10 show a first embodiment of the present invention wherein the edge type contact trace is coupled to an interconnect pad provided on a printed circuit board. In the first example of Figure 7, a contact structure 30 formed on a contact substrate 20 is electrically connected to a contact trace 32 which is the edge type contact trace noted above. Typically, the contact substrate 20 is a silicon substrate although other types of dielectric substrate, such as glass epoxy, polyimide, ceramic, and alumina substrates are also feasible. The contact trace 32 is connected at its end with a printed circuit board (PCB) interconnect pad 38 provided on a PCB substrate 62. At about the center of Figure 7, the contact substrate 20 is mounted on the PCB substrate 62 through an elastomer 42 and a support structure 52. The contact substrate 20, the elastomer 42, the support structure 52 and the PCB substrate 62 are fixed with one another by, for example, an adhesive (not shown).

The electrical connection between the contact trace 32 and the PCB pad 38 will be established by various bonding technologies including thermosonic bonding, thermocompression bonding, and ultrasonic bonding technique. In another aspect, such an electrical connection will be established through a surface mount technology (SMT) such as using a screen printable solder paste. A soldering process is carried out based on the reflow characteristics of the solder paste and other solder materials well known in the art.

The PCB substrate 62 itself may be a probe card such as shown in Figure 3 or provided separately and mounted directly or indirectly on the probe card. In the former case, the PCB 62 may make direct contact with an interface of a test system such as an IC tester in a manner shown in Figure 2. In the latter case, the PCB substrate 62 is pinned or in use of a conductive polymer for establishing an electrical contact to the next level of a contact mechanism on the probe card. Such types of electrical connection between the PCB substrate 62 and the probe card through pins or conductive polymer would allow for field repairability.

The PCB substrate 62 may be a multiple layer structure which is capable of providing high bandwidth signals, distributed high frequency capacitance and integrated high frequency chip capacitors for power supply decoupling as well as high pin counts (number of I/O pins and associated signal paths). An example of material of the PCB 62 is standard high performance glass epoxy resin. Another example of material is ceramics which is expected to minimize mismatch in coefficient of temperature expansion (CTE) rates during high temperature application such as a burn-in test of semiconductor wafers and packaged IC devices.

The support structure 52 is to establish a physical strength of the packaging and interconnection of the contact structure. The support structure 52 is made of, for example, ceramic, molded plastic or metal. The elastomer 42 is to establish flexibility in the packaging and interconnection of the present invention to overcome a potential planarization mechanism. The elastomer 42 also functions to absorb a mismatch in temperature expansion rates between the contact substrate 20 and the PCB substrate 62.

An example of length of the contact trace 32 is in the range from several ten micrometers to several hundred micrometers. Because of the short path length, the packaging interconnection of the present invention can be easily

operable in a high frequency band such as several GHz or even higher. Moreover, because of a relatively small number of overall components to be assembled, the packaging and interconnection of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Figure 8 shows another example of the first embodiment of the present invention. A contact trace 32₂ is bent downward and is shaped like a gull-wing which is similar to the standard "gull-wing lead" used in a surface mount technology. Because of the gull-wing of the contact trace 32₂, a vertical position of the PCB interconnect pad 38 on a PCB substrate 62, is lower than that of Figure 7. In other words, the thickness of the left portion of the PCB substrate 62, is smaller than that of the PCB substrate 62 of Figure 7. Thus, the example of Figure 8 provides an additional clearance in a vertical dimension over the contact portion between the PCB pad 38 and the contact trace 32₂.

The lead form of the contact trace 32₂, noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Since a large number of interconnection between the contact trace and the PCB pad will be used in the application such as semiconductor testing, several hundred connections, such tooling may be standardized for a multiple of contact traces with given pitch.

The electrical connection between the contact trace 32₂ and the PCB pad 38 will be established by a surface mount technology (SMT) such as using a screen printable solder paste as well as various other bonding technologies including thermosonic bonding, thermocompression bonding, and ultrasonic bonding technique. Because of the significantly small sizes of the components and signal path lengths involved in the contact structure 30 and contact trace 32₂, the example of Figure 8 can operate at a very high frequency band, such as several GHz. Moreover, because of the small

number and simple structure of components to be assembled, the interconnection and packaging of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Figure 9 shows a further example of the first embodiment of the present invention. In this example, two gull-wing leads A and B are provided to a contact trace 32, connected to the contact structure 30. The gull-wing lead A is provided in an upper and outer position of Figure 9 than the gull-wing lead B. The gull-wing lead A is connected to a PCB pad 38 and the gull-wing B lead is connected to a PCB pad 39. To accommodate the PCB pads 38 and 39 thereon, a PCB substrate 62, is arranged to have an edge portion having a larger thickness, i.e., a step, to mount the PCB pad 38, and an inner portion adjacent to the edge portion having a smaller thickness to mount the PCB pad 39.

The lead form of the contact trace 32, noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch. The electrical connection between the contact trace 32, and the PCB pads 38 and 39 will be established by the surface mount technology such as using the screen printable solder paste as well as various other bonding technologies including thermosonic bonding, thermocompression bonding, and ultrasonic bonding technique.

The structure of contact trace 32, having the tiered gull-wing leads A and B establish a fan out in the vertical dimension. This is useful in distributing a signal or power to two or more paths. Another advantage of the fan out is to increase the number of contact pads, i.e., to decrease the effective pitch (distance) between the contact pads. Similar to the example of Figure 8, the contact trace 32, of Figure 9 provides an additional clearance in a vertical dimension above the contact portions between contact trace 32, and the

PCB pads 38 and 39.

Figure 10 shows a further example of the first embodiment of the present invention. In this example, a contact trace 32₄ is shaped like a J-lead commonly used in the surface mount technology. The J-lead is formed at the edge of a contact substrate 20₂ in a manner to surround the substrate edge. The bottom surface of the contact trace 32₄ (J-lead) is connected to a PCB pad 38₂ on a PCB substrate 62₄. As shown in Figure 10, the shapes of a support structure 52₂ and the PCB substrate 62₄ are slightly different from that of the previous examples to meet the J-lead shape of the contact trace 32₄.

The lead form of the contact trace 32₄ noted above (J-lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch. The electrical connection between the contact trace 32₄ and the PCB pad 38₂ will be established by the SMT technology such as using the screen printable solder paste as well as various other bonding technologies including thermosonic bonding, thermocompression bonding, ultrasonic bonding technique and the like.

The structure of the contact trace 32₄ having the J-lead can establish an improved physical strength because a large portion of which is supported by the contact substrate 20₂. The further advantage of this example is that the length of the contact trace 32₄ is about the same as that of the contact substrate 20₂. In other words, the lead form and the attachment to the PCB substrate in Figure 10 does not consume any additional horizontal area than that consumed by the contact substrate 20₂.

Figures 11 and 12 show a second embodiment of the present invention wherein the edge type contact trace is coupled to a connector provided on a printed circuit board or other structure. In the example of Figure 11, a contact trace 32₅ is formed on a contact substrate 20 and is

connected to a connector 46 provided on a support structure 52,. Typically, the contact substrate 20 is a silicon substrate although other types of dielectric substrate, such as glass epoxy, polyimide, ceramic, and alumina substrates are also feasible.

In this example, the contact trace 32, has a shape similar to the gull-wing widely used in the surface mount technology and incorporated in the example of Figure 8. At about the center of Figure 11, the contact substrate 20 is mounted on the support structure 52, through an elastomer 42. The contact substrate 20, the elastomer 42 and the support structure 52, are attached with one another by, for example, an adhesive (not shown).

The connector 46 may be mechanically fixed to the support structure 52, through an attachment mechanism (not shown). The end of the contact trace 32, is inserted in a receptacle (not shown) of the connector 46. As is well known in the art, such a receptacle has a spring mechanism to provide a sufficient contact force when receiving the end of the contact trace 32, therein. Also well known in the art, an inner surface of such a receptacle is provided with conductive metal such as gold, silver, palladium or nickel.

The connector 46 may be integrated with straight or right angle pins, which may be connected to the receptacle noted above, for direct connection to a printed circuit board (PCB). A PCB to mount the connector 46 thereon can be either solid or flexible. As is known in the art, a flexible PCB is formed on a flexible base material and has flat cables thereon. Alternatively, the connector 46 may be integrated with a coaxial cable assembly in which a receptacle is attached to an inner conductor of the coaxial cable for receiving the contact trace 32, therein. The connection between the connector 46 and the contact trace 32, or the support structure 52, is not a permanent attachment method, allowing for field replacement and repairability of the

contact portion.

Typically, the contact substrate 20 is a silicon substrate although other types of substrate, such as glass epoxy, polyimide, ceramic, and alumina substrates are also feasible. The support structure 52, is to establish a physical strength of the packaging and interconnection of the contact structure. The support structure 52, is made of, for example, ceramic, molded plastic or metal. The elastomer 42 is to establish flexibility in the interconnection and packaging of the present invention to overcome a potential planarization mechanism. The elastomer 42 also functions to absorb a mismatch in temperature expansion rates between the contact substrate 20 and a PCB substrate to mount the connector 46 thereon.

An example of length of the contact trace 32, is in the range from several ten micrometers to several hundred micrometers. Because of the short path length, the interconnection and packaging of the present invention can be easily operable in a high frequency band such as several GHz or even higher. Moreover, because of the lower total number of components to be assembled, the packaging and interconnection of the present invention can be fabricated with low cost and high reliability as well as high productivity. The gull-wing shaped contact trace 32, may require special tooling in the production process, which may be standardized for a multiple of contact traces with a given pitch. The shape of the contact trace 32, provides for additional top side clearance in the vertical dimension.

Figure 12 shows another example of the second embodiment of the present invention. In this example, two leads A and B are provided to a contact trace 32, connected to the contact structure 30. The leads A and B are gull-wing shaped similar to the example of Figure 11. The lead A is positioned over the lead B as shown in Figure 9. The leads A and B are inserted in corresponding receptacles (not shown)

of a connector 46₂ to establish the electrical connection therebetween. The connector 46₂ is mechanically attached on a support structure 52₃.

The lead form of the contact trace 32₆ noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch. The structure of contact trace 32₆ having the tiered gull-wing leads A and B can establish a fan out in the vertical dimension. This is useful in distributing a signal or power to two or more conductive paths. Other advantage is to increase the number of contact pads, i.e., to decrease the effective pitch (distance) between the contact pads. Similar to the example of Figure 11, the contact trace 32₆ of Figure 12 provides an additional clearance in a vertical dimension over the contact trace 32₆ and the connector 46₂.

Figures 13-16 show a third embodiment of the present invention wherein the edge type contact trace is coupled to a pad provided on a printed circuit board through a conductive bump. In the example of Figure 13, a contact trace 32 is formed on a contact substrate 20. Typically, the contact substrate 20 is a silicon substrate although other types of dielectric substrate, such as glass epoxy, polyimide, ceramic, and alumina substrates are also feasible. The contact trace 32 is connected to a PCB (print circuit board) pad 38 provided on a PCB substrate 62₅ through a conductive bump 56.

In this example, the contact trace 32 has the same straight shape as that shown in the example of Figure 7. At about the center of Figure 13, the contact substrate 20 is mounted on the PCB substrate 62₅ through a support structure 52 and an elastomer 42. The contact substrate 20, the elastomer 42, the support structure 52, and the PCB substrate 62₅ are attached with one another by, for example, an adhesive (not shown).

By the application of the heat, the conductive bump 56 is reflowed onto the PCB pad 38 for attachment between the contact trace 32 and the PCB pad 38. An example of the conductive bump 56 is a solder bump used in a standard solder ball technology. Another example of the conductive bump 56 is a fluxless solder ball used in a plasma-assisted dry soldering technology.

Further examples of the conductive bump 56 are a conductive polymer bump and a compliant bump which involve the use of polymer in the bump. This helps in minimizing planarization problems or CTE (coefficient of temperature expansion) mismatches in the packaging and interconnection. There is no reflowing of metal, which prevents bridging between contact points. The conductive polymer bump is made of a screen printable conductive adhesive. The compliant bump is a polymer core bump with a metal coating. The polymer is typically plated with gold and is elastically compressible. Still further example of the conductive bump 56 is a bump used in a controlled collapse chip connection technology in which solder balls are formed by an evaporation process.

The PCB substrate 62, itself may be a probe card such as shown in Figure 3 or provided separately and mounted directly or indirectly on the probe card. In the former case, the PCB substrate 62, may make direct contact with an interface of a test system such as an IC tester in the manner shown in Figure 2. In the latter case, the PCB substrate 62, is pinned or in use of a conductive polymer for establishing an electrical contact to the next level. Such types of electrical connection between the PCB substrate 62, and the probe card through pins or conductive polymer would allow for field repairability.

The PCB substrate 62, may be a multiple layer structure which is capable of providing high bandwidth signals, distributed high frequency capacitance and integrated high

frequency chip capacitors for power supply decoupling as well as high pin counts (number of I/O pins and associated signal paths). An example of material of the PCB substrate 62₅ is standard high performance glass epoxy resin. Another example of the material is ceramics which is expected to minimize mismatch in coefficient of temperature expansion (CTE) rates during high temperature application such as a burn-in test of semiconductor wafers and packaged IC devices.

The support structure 52 is to establish a physical strength of the packaging and interconnection of the contact structure. The support structure 52 is made of, for example, ceramic, molded plastic or metal. The elastomer 42 is to establish flexibility in the packaging and interconnection of the present invention to overcome a potential planarization mechanism. The elastomer 42 also functions to absorb a mismatch in temperature expansion rates between the contact substrate 20 and the PCB substrate 62₅.

An example of length of the contact trace 32 is in the range from several ten micrometers to several hundred micrometers. Because of the short path length, the interconnection and packaging of the present invention can be easily operable in a high frequency band such as several GHz or even higher. Moreover, because of the lower total number of components to be assembled, the packaging and interconnection of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Figure 14 shows another example of the third embodiment of the present invention. A contact trace 32, is bent downward and is shaped like a gull-wing which is similar to the standard "gull-wing lead" used in a surface mount technology and incorporated in the examples of Figures 8 and 11. Because of the gull-wing shape of the contact trace 32,, a PCB interconnect pad 38 on a PCB substrate 62₆ is positioned lower than that of Figure 13. In this example,

the PCB substrate 62, has a planer surface throughout and has no step thereon. Thus, this example provides an additional clearance in the vertical dimension over the contact portion between the PCB pad 38 and the contact trace 32.

The lead form of the contact trace 32, noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with given pitch. Because of the extremely small sizes of the components therein and short path length of the contact structure 30 and contact trace 32,, the example of Figure 14 can operate at a high frequency band such as several GHz. Moreover, because of the small number and simple structure of components to be assembled, the packaging and interconnection of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Figure 15 shows a further example of the third embodiment of the present invention. In this example, two gull-wing leads A and B are provided to a contact trace 32, connected to the contact structure 30. The gull-wing lead A is provided in an upper and outer position of Figure 15 than the gull-wing lead B. The gull-wing lead A is connected to a PCB interconnect pad 38 through a conductive bump 56 and the gull-wing lead B is connected to a PCB interconnect pad 39 through a conductive bump 57. To accommodate the PCB interconnect pads 38 and 39 thereon, a PCB substrate 62, is arranged to have an edge portion having a larger thickness, i.e., a step, to mount the PCB pad 38 thereon, and an inner portion adjacent to the edge portion having a smaller thickness to mount the PCB pad 39 thereon.

The lead form of the contact trace 32, noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch. The structure of the contact trace 32, having the tiered gull-wing leads A

and B can establish a fan out in the vertical dimension. This is useful in distributing a signal or power to two or more paths. Other advantage is to increase the number of contact pads, i.e., to decrease the effective pitch (distance) between the contact pads. Similar to the example of Figure 14, the contact trace 32, of Figure 15 provides an additional clearance in the vertical dimension over the contact portions formed by the contact trace 32, and the PCB pads 38 and 39.

Figure 16 shows a further example of the third embodiment of the present invention. In this example, a contact trace 32, is shaped like a J-lead commonly used in the surface mount technology. The J-lead is formed at the edge of a contact substrate 20, in a manner to surround the edge of the substrate. The bottom surface of the contact trace 32, (J-lead) is connected to a PCB pad 38 on a PCB substrate 62, through a conductive bump 56. The shapes of a support structure 52, and the PCB substrate 62, are slightly different from that of the previous examples to meet the shape of the contact trace 32,. The lead form of the contact trace 32, noted above (J-lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch.

The structure of contact trace 32, having the J-lead can establish an improved physical strength because a large portion of which is supported by the contact substrate 20,. The further advantage of this example is that the length of the contact trace 32, is about the same as that of the contact substrate 20,. In other words, the lead form and the attachment to the PCB substrate in Figure 16 does not consume any additional horizontal area than that consumed by the contact substrate 20,.

Figures 17-20 show a fourth embodiment of the present invention wherein the edge type contact trace is coupled to a pad provided on a printed circuit board through a

conductive polymer. In the example of Figure 17, a contact trace 32 is formed on a contact substrate 20 and is connected to a PCB (print circuit board) pad 38 provided on a PCB substrate 62, through a conductive polymer 66. Typically, the contact substrate 20 is a silicon substrate although other types of dielectric substrate, such as glass epoxy, polyimide, ceramic, and alumina substrates are also feasible.

In this example, the contact trace 32 has the same straight shape as that shown in the example of Figures 7 and 13. At about the center of Figure 17, the contact substrate 20 is mounted on the PCB substrate 62, through a support structure 52 and an elastomer 42. The contact substrate 20, the elastomer 42, the support structure 52, and the PCB substrate 62, are attached with one another by, for example, an adhesive (not shown).

Most conductive polymers are designed to be conductive between the mating electrodes normally in vertical or angled directions and not conductive in the horizontal direction. An example of the conductive polymer 66 is a conductive elastomer which is filled with conductive wire that extends beyond the surface of the elastomer.

Various other examples of the conductive polymer 66 are possible such as an anisotropic conductive adhesive, anisotropic conductive film, anisotropic conductive paste, and anisotropic conductive particles. The anisotropic conductive adhesive is filled with conductive particles that do not touch each other. The conductive path is formed by pressing the adhesive between the two electrodes at a specific location. The anisotropic conductive film is a thin dielectric resin filled with conductive particles that do not touch each other. The conductive path is formed by pressing the film between the two electrodes at a specific location.

The anisotropic conductive paste is a screen printable paste which is filled with conductive particles that do not touch each other. The conductive path is formed by pressing

the paste between the two electrodes at a specific location. The anisotropic conductive particle is a thin dielectric resin filled with conductive particles coated with a very thin layer of dielectric material to improve isolation. The conductive path is formed by pressing the particle with enough force to explode the dielectric coating on the particles, between the two electrodes at a specific location.

The PCB substrate 62, itself may be a probe card such as shown in Figure 3 or provided separately and mounted directly or indirectly on the probe card. In the former case, the PCB substrate 62, may make direct contact with an interface of a test system such as an IC tester in the manner shown in Figure 2. In the latter case, the PCB substrate 62, is pinned or in use of a conductive polymer for establishing an electrical contact to the next level. Such types of electrical connection between the PCB substrate 62, and the probe card through pins or conductive polymer would allow for field repairability.

The PCB substrate 62, may be a multiple layer structure which is capable of providing high bandwidth signals, distributed high frequency capacitance and integrated high frequency chip capacitors for power supply decoupling as well as high pin counts (number of I/O pins and associated signal paths). An example of material of the PCB substrate 62, is standard high performance glass epoxy resin. Another example of material is ceramics which is expected to minimize mismatch in coefficient of temperature expansion (CTE) rates during high temperature application such as a burn-in test of semiconductor wafers and packaged IC devices.

The support structure 52 is to establish a physical strength of the packaging and interconnection of the contact structure. The support structure 52 is made of, for example, ceramic, molded plastic or metal. The elastomer 42 is to establish flexibility in the packaging and interconnection of the present invention to overcome a potential planarization

mechanism. The elastomer 42 also functions to absorb a mismatch in temperature expansion rates between the contact substrate 20 and the PCB substrate 62₅.

An example of length of the contact trace 32 is from several ten micrometers to several hundred micrometers. Because of the short path length, the packaging and interconnection of the present invention can be easily operable in a high frequency band such as several GHz or even higher. Moreover, because of the lower total number of components to be assembled, the interconnection and packaging of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Figure 18 shows another example of the fourth embodiment of the present invention. A contact trace 32, is bent downward and is shaped like a gull-wing which is similar to the standard "gull-wing lead" used in a surface mount technology and incorporated in the examples of Figures 8, 11 and 14. Because of the gull-wing shape of the contact trace 32,, a PCB interconnect pad 38 on a PCB substrate 62₆ is positioned lower than that of Figure 17. In this example, the PCB substrate 62₆ has a planer surface throughout and has no step thereon. Thus, the example of Figure 18 provides an additional clearance in a vertical dimension over the contact portion among the PCB interconnect pad 38, the conductive polymer 66, and the contact trace 32,.

The lead form of the contact trace 32, noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with given pitch. Because of the extremely small sizes of the components therein and short path length of the contact structure 30 and contact trace 32,, the example of Figure 18 can operate at a high frequency band. Moreover, because of the small number and simple structure of components to be assembled, the interconnection and packaging of the present invention can be fabricated with

low cost and high reliability as well as high productivity.

Figure 19 shows a further example of the fourth embodiment of the present invention. In this example, two gull-wing leads A and B are provided to a contact trace 32, connected to the contact structure 30. The gull-wing lead A is provided in an upper and outer position of Figure 15 than the gull-wing lead B. The gull-wing lead A is connected to a PCB interconnect pad 38 through a conductive polymer 66 and the gull-wing lead B is connected to a PCB interconnect pad 39 through the conductive polymer 67. To accommodate the PCB interconnect pads 38 and 39 thereon, a PCB substrate 62, is arranged to have an edge portion having a larger thickness, i.e., a step, to mount the PCB pad 38 thereon and an inner portion adjacent to the edge portion having a smaller thickness to mount the PCB pad 39 thereon.

The lead form of the contact trace 32, noted above (downward bent, gull-wing lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch. The structure of contact trace 32, having the tiered gull-wing leads A and B can establish a fan out in the vertical dimension. This is useful in distributing a signal or power to two or more paths. Other advantage of the fan out is to increase the number of contact pads, i.e., to decrease the effective pitch (distance) between the contact pads. Similar to the example of Figure 18, the contact trace 32, of Figure 19 provides an additional clearance in the vertical dimension over the contact portions formed between contact trace 32, and the PCB pads 38 and 39.

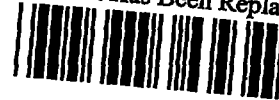
Figure 20 shows a further example of the fourth embodiment of the present invention. In this example, a contact trace 32, is shaped like a J-lead commonly used in the surface mount technology. The J-lead is formed at the edge of a contact substrate 20, in a manner to surround the edge thereof. The bottom surface of the contact trace 32,

(J-lead) is connected to a PCB interconnect pad 38 on a PCB substrate 62, through the conductive polymer 66. The shapes of a support structure 52, and the PCB substrate 62, are slightly different from that of the previous examples to meet the shape of the contact trace 32.

The lead form of the contact trace 32, noted above (J-lead) may require special tooling to produce the same. Such tooling may be standardized for a multiple of contact traces with a given pitch. The structure of contact trace 32, having the J-lead can establish an improved physical strength because a large portion of which is supported by the contact substrate 20. The further advantage of this example is that the length of the contact trace 32, is about the same as that of the contact substrate 20. In other words, the lead form and the attachment method to the PCB substrate in Figure 20 does not consume any additional horizontal area than that consumed by the contact substrate 20.

According to the present invention, the packaging and interconnection has a very high frequency bandwidth to meet the test requirements in the next generation semiconductor technology. The packaging and interconnection is able to mount the contact structure on a probe card or equivalent thereof by electrically connecting therewith through the edge of the contact structure. Moreover, because of a relatively small number of overall components to be assembled, the interconnection and packaging of the present invention can be fabricated with low cost and high reliability as well as high productivity.

Although only a preferred embodiment is specifically illustrated and described herein, it will be appreciated that many modifications and variations of the present invention are possible in light of the above teachings and within the purview of the appended claims without departing the spirit and intended scope of the invention.



WHAT IS CLAIMED IS:

1. A packaging and interconnection of a contact structure, comprising:

a contact structure made of conductive material and formed on a contact substrate through a photolithography process, said contact structure having a base portion vertically formed on said contact substrate, a horizontal portion, one end of which being formed on said base portion, and a contact portion vertically formed on another end of said horizontal portion;

a contact trace formed on said contact substrate and electrically connected to said contact structure at one end, the other end of said contact trace being extended toward an edge of said contact substrate;

a printed circuit board (PCB) pad provided on a printed circuit board (PCB) substrate to be electrically connected with said other end of said contact trace;

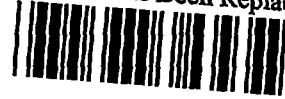
an elastomer provided under said contact substrate for allowing flexibility in said interconnection and packaging; and

a support structure provided between said elastomer and said PCB substrate for supporting said contact structure, said contact substrate and said elastomer.

2. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said contact substrate is a silicon substrate on which said contact structure is directly formed through said photolithography process.

3. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said contact substrate is a dielectric substrate on which said contact structure is directly formed through said photolithography process.

4. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said contact trace



is made of conductive material and formed through either a deposition, evaporation, sputtering or plating process.

5. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said PCB substrate is made of glass epoxy resin or ceramics.

6. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said PCB substrate is a multilayer printed circuit board.

7. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said support structure is made of ceramic, molded plastic or metal.

8. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said electrical connection between said other end of said contact trace and said PCB pad is established by wire bonding or soldering.

9. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said other end of said contact trace is formed of a gull-wing lead to be electrically connected to said PCB pad.

10. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said other end of said contact trace is formed of a gull-wing lead having an end portion thereof which is substantially parallel with a surface of said PCB pad.

11. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said other end of said contact trace is formed of at least two gull-wing leads to be electrically connected to corresponding PCB pads provided on said PCB substrate.

12. A packaging and interconnection of a contact structure as defined in Claim 11, wherein said at least two gull-wing leads are aligned in a substantially vertical relationship with one another.

13. A packaging and interconnection of a contact structure as defined in Claim 1, wherein said other end of



said contact trace is formed of a J-lead to be electrically connected to said PCB pad.

14. A packaging and interconnection of a contact structure, comprising:

- a contact structure made of conductive material and formed on a contact substrate through a photolithography process, said contact structure having a base portion vertically formed on said contact substrate, a horizontal portion, one end of which being formed on said base portion, and a contact portion vertically formed on another end of said horizontal portion;

- a contact trace formed on said contact substrate and electrically connected to said contact structure at one end, the other end of said contact trace being extended toward an edge of said contact substrate;

- a connector for receiving said other end of said contact trace for establishing electrical connection therebetween;

- an elastomer provided under said contact substrate for allowing flexibility in said interconnection and packaging; and

- a support structure provided under said elastomer for supporting said contact structure, said contact substrate, said elastomer and said connector.

15. A packaging and interconnection of a contact structure as defined in Claim 14, wherein said contact substrate is a silicon substrate on which said contact structure is directly formed through said photolithography process.

16. A packaging and interconnection of a contact structure as defined in Claim 14, wherein said contact substrate is a dielectric substrate on which said contact structure is directly formed through said photolithography process.

17. A packaging and interconnection of a contact



structure as defined in Claim 14, wherein said contact trace is made of conductive material and formed through either a deposition, evaporation, sputtering or plating process.

18. A packaging and interconnection of a contact structure as defined in Claim 14, wherein said support structure is made of ceramic, molded plastic or metal.

19. A packaging and interconnection of a contact structure as defined in Claim 14, wherein said other end of said contact trace is formed of a gull-wing lead to be electrically connected to said connector.

20. A packaging and interconnection of a contact structure as defined in Claim 14, wherein said other end of said contact trace is formed of a gull-wing lead having an end portion thereof which is substantially parallel with said support structure.

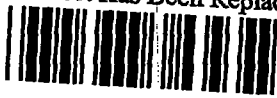
21. A packaging and interconnection of a contact structure as defined in Claim 14, wherein said other end of said contact trace is formed of at least two gull-wing leads to be electrically connected to corresponding receptacles of said connector.

22. A packaging and interconnection of a contact structure as defined in Claim 21, wherein said at least two gull-wing leads are aligned in a substantially vertical relationship with one another.

23. A packaging and interconnection of a contact structure, comprising:

- a contact structure made of conductive material and formed on a contact substrate through a photolithography process, said contact structure having a base portion vertically formed on said contact substrate, a horizontal portion, one end of which being formed on said base portion, and a contact portion vertically formed on another end of said horizontal portion;

- a contact trace formed on said contact substrate and electrically connected to said contact structure at



one end, the other end of said contact trace being extended toward an edge of said contact substrate;

a printed circuit board (PCB) pad provided on a printed circuit board (PCB) substrate to be electrically connected with said other end of said contact trace;

a conductive bump provided between said other end of said contact trace and said PCB pad to establish electrical connection therebetween;

an elastomer provided under said contact substrate for allowing flexibility in said interconnection and packaging; and

a support structure provided between said elastomer and said PCB substrate for supporting said contact structure, said contact substrate and said elastomer.

24. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said contact substrate is a silicon substrate on which said contact structure is directly formed through said photolithography process.

25. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said contact substrate is a dielectric substrate on which said contact structure is directly formed through said photolithography process.

26. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said contact trace is made of conductive material and formed through either a deposition, evaporation, sputtering or plating process.

27. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said PCB substrate is made of glass epoxy resin or ceramics.

28. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said PCB substrate is a multilayer printed circuit board.

29. A packaging and interconnection of a contact



structure as defined in Claim 23, wherein said support structure is made of ceramic, molded plastic or metal.

30. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said conductive bump is a solder ball which reflows by application of heat to electrically connect said other end of said contact trace and said PCB pad.

31. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said conductive bump is a conductive polymer bump or a compliant bump to electrically connect said other end of said contact trace and said PCB pad.

32. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said other end of said contact trace is formed of a gull-wing lead to be electrically connected to said PCB pad.

33. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said other end of said contact trace is formed of at least two gull-wing leads to be electrically connected to corresponding PCB pads provided on said PCB substrate through corresponding conductive bumps.

34. A packaging and interconnection of a contact structure as defined in Claim 33, wherein said at least two gull-wing leads are aligned in a substantially vertical relationship with one another.

35. A packaging and interconnection of a contact structure as defined in Claim 23, wherein said other end of said contact trace is formed of a J-lead to be electrically connected to said PCB pad through said conductive bump.

36. A packaging and interconnection of a contact structure, comprising:

a contact structure made of conductive material and formed on a contact substrate through a photolithography process, said contact structure having a base portion



vertically formed on said contact substrate, a horizontal portion, one end of which being formed on said base portion, and a contact portion vertically formed on another end of said horizontal portion;

a contact trace formed on said contact substrate and electrically connected to said contact structure at one end, the other end of said contact trace being extended toward an edge of said contact substrate;

a printed circuit board (PCB) pad provided on a printed circuit board (PCB) substrate to be electrically connected with said other end of said contact trace;

a conductive polymer provided between said other end of said contact trace and said PCB pad to establish electrically connection thereamong;

an elastomer provided under said contact substrate for allowing flexibility in said interconnection and packaging; and

a support structure provided between said elastomer and said PCB substrate for supporting said contact structure, said contact substrate and said elastomer.

37. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said contact substrate is a silicon substrate on which said contact structure is directly formed through said photolithography process.

38. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said contact substrate is a dielectric substrate on which said contact structure is directly formed through said photolithography process.

39. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said contact trace is made of conductive material and formed through either a deposition, evaporation, sputtering or plating process.

40. A packaging and interconnection of a contact



structure as defined in Claim 36, wherein said PCB substrate is made of glass epoxy resin or ceramics.

41. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said PCB substrate is a multilayer printed circuit board.

42. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said support structure is made of ceramic, molded plastic or metal.

43. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said conductive polymer is a conductive adhesive, conductive film, conductive paste or conductive particles.

44. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said conductive polymer is a conductive elastomer including an anisotropic conductive adhesive, anisotropic conductive film, anisotropic conductive paste or anisotropic conductive particles to electrically connect said other end of said contact trace and said PCB pad.

45. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said other end of said contact trace is formed of a gull-wing lead to be electrically connected to said PCB pad.

46. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said other end of said contact trace is formed of a gull-wing lead having an end portion thereof which is substantially parallel with a surface of said PCB pad.

47. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said other end of said contact trace is formed of at least two gull-wing leads to be electrically connected to corresponding PCB pads provided on said PCB substrate through corresponding conductive polymer.

48. A packaging and interconnection of a contact



structure as defined in Claim 36, wherein said at least two gull-wing leads are aligned in a substantially vertical relationship with one another.

49. A packaging and interconnection of a contact structure as defined in Claim 36, wherein said other end of said contact trace is formed of a J-lead to be electrically connected to said PCB pad through said conductive polymer.