

CONTACT STRUCTURE AND PRODUCTION METHOD THEREOF
AND PROBE CONTACT ASSEMBLY USING SAME

Field of the Invention

5 This invention relates to a contact structure and a
production method thereof and a probe contact assembly using
the contact structure. More particularly, this invention
relates to a contact structure having a large number of
contactors in a vertical direction. This invention further
10 relates to a method for producing such a large number of
contactors on a semiconductor wafer in a horizontal direction
and removing the contactors from the wafer to be mounted on
a substrate in a vertical direction to form a contact
structure such as a contact probe assembly, probe card, IC
chip, or other contact mechanism.

15 Background of the Invention

In testing high density and high speed electrical
devices such as LSI and VLSI circuits, a high performance
contact structure such as a probe card having a large number
of contactors must be used. In other applications, contact
20 structures may be used for IC packages as leads or terminals.
The present invention is directed to such contact structures
to be used in testing LSI and VLSI chips, semiconductor
wafers, burn-in of semiconductor wafers and dice, testing and
burn-in of packaged semiconductor devices, printed circuit
25 boards and the like. The present invention can also be
applicable to other purposes such as leads or terminal pins
of IC chips, IC packages or other electronic devices.
However, for the convenience of explanation, the present
invention is described mainly with reference to the
30 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
35 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 110. The test head 100 and a substrate handler 400 are mechanically as well as electrically connected with one another with the aid of a manipulator 500 which is driven by a motor 510. The semiconductor wafers to be tested are automatically provided to a test position of the test head 100 by the substrate handler 400.

On the test head 100, 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 (IC circuits formed on the semiconductor wafer) are transmitted to the semiconductor test system. In the semiconductor test system, the output signals are compared with expected data to determine whether the IC circuits on the semiconductor wafer function correctly.

In Figure 2, the test head 100 and the substrate handler 400 are connected through 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 (test pins) of the semiconductor test system. Each of the printed circuit boards 150 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.

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. In this example, 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 contact targets such as circuit terminals or contact pads of the IC circuit on the semiconductor wafer 300 under test.

Electrical terminals or contact receptacles (contact pads) 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 the 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, for example, several hundreds of inner cables.

Under this arrangement, the probe contactors 190 contact the surface (contact target) 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 IC circuits on 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 also 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 (contact targets) 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 (contact pads) 197 which are in communication with the pogo pins 141 of Figure 2.

5 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
10 by balancing the distributed parameters, i.e., dielectric constant and magnetic permeability of the polyimide, inductances and capacitances of the signal paths within the probe card 170. Thus, the signal lines are impedance matched lines establishing a high frequency transmission bandwidth
15 for supplying currents to the wafer 300 in a steady state as well as high current peaks generated by the device's outputs switching in a transient state. For removing noise, capacitors 193 and 195 are provided on the probe card 170 between the power plane and the ground plane.

20 An equivalent circuit of the probe card 170 is shown in Figure 4 to illustrate the limitation in the high frequency performance in the probe card of Figure 3. As shown in Figures 4A and 4B, the signal transmission line on the probe card 170 extends from the electrode 197, a strip line 196
25 which is impedance matched, a wire 194 and the needle or cantilever (contact structure) 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
30 needle 190 can be around 20-30mm, significant limitations will be resulted from the inductor when 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
35 in Figures 4D and 4E. 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 the inductors as noted above, the high speed current flow is seriously restricted.

5 Moreover, the capacitors 193 and 195 are provided between the power plane and the ground plane 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
10 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. In other words, the capacitors limit the
15 high frequency performance of the probe contactor.

 Accordingly, the most widely used probe card such as above are limited to the frequency bandwidth of around 200MHz which is insufficient to test recent semiconductor devices. In the industry, it is considered that the frequency
20 bandwidth comparable 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
25 more, in a parallel fashion to increase test throughput.

 In the conventional technology, the probe card such as shown in Figure 3 are manually made, resulting in inconsistent quality. Such inconsistent quality includes fluctuations of size, frequency bandwidth, contact forces and
30 resistance, etc. In the conventional probe contactors, another factor making the contact performance unreliable is a temperature change under which the probe contactors and the semiconductor wafer under test have different temperature expansion ratios. Thus, under the varying temperature, the
35 contact positions therebetween vary which adversely affects the contact force, contact resistance and bandwidth. Thus,

there is a need of a contact structure with a new concept which can satisfy the requirement in the next generation semiconductor test technology.

Summary of the Invention

5 Therefore, it is an object of the present invention to provide a contact structure having a large number of contactors for electrically contacting contact targets with a high frequency bandwidth, high pin counts and high contact performance as well as high reliability.

10 It is another object of the present invention to provide a contact structure such as a probe card to establish electrical connection for testing semiconductor devices and the like, having a very high frequency bandwidth to meet the test requirements in the next generation semiconductor test
15 technology.

 It is a further object of the present invention to provide a contact structure to establish electrical connection in applications such as testing semiconductor devices, which are suitable for testing a large number of
20 semiconductor devices in parallel at the same time.

 It is a further object of the present invention to provide a contact structure and its assembly mechanism for assembling a plurality of contact structures to form a probe contact assembly of desired size with desired number of
25 contactors mounted on the probe contact assembly.

 It is a further object of the present invention to provide a method for producing a large number of contactors in a two dimensional manner on a silicon substrate, removing the contactors from the substrate and mounting the contactors
30 on a contact substrate in a three dimensional manner to form a contact structure.

 It is a further object of the present invention to provide a method for producing a large number of contactors in a two dimensional manner on a silicon substrate,
35 transferring the contactors to an adhesive tape and removing the contactors therefrom for vertically mounting the same on

a contact substrate to form a contact structure.

In the present invention, a contact structure for testing devices under test are formed of a large number of contactors produced on a planar surface of a silicon substrate by a photolithography technology established in the semiconductor production process. The contact structure of the present invention can also be used as components of electronics devices such as IC leads and pins.

The first aspect of the present invention is a contact structure for establishing electrical connection with contact targets. The contact structure is formed of a contact substrate and a plurality of contactors in which each of the contactors has a substantially straight shape. The contactor is comprised of a tip portion which is protruded in a vertical direction to form a contact point, a base portion which is inserted in a through hole provided on the contact substrate in such a way that an end of the contactor functions as a contact pad for electrical connection at a bottom surface of the contact substrate, and a spring portion provided between the tip portion and the base portion which produces a resilient contact force when the contactor is pressed against the contact target.

Another aspect of the present invention is a method of producing the contactors in a two dimensional manner on a silicon substrate and removing therefrom for establishing a contact structure. The production method is comprised of the following steps of:

(a) forming a sacrificial layer on a surface of a silicon substrate;

(b) forming a photoresist layer on the sacrificial layer;

(c) aligning a photo mask over the photoresist layer and exposing the photoresist layer with ultraviolet light through the photo mask, the photo mask including an image of the contactors;

(d) developing patterns of the image of the contactors

on a surface of the photoresist layer;

(e) forming a first layer of contactors made of electric conductive material in the patterns on the photoresist layer by an electroplating process;

5 (f) repeating the steps (b)-(e) above on the first layer of contactors to form a second layer or higher layer of the contactors;

(g) stripping the photoresist layer off;

(h) removing the sacrificial layer by an etching process
10 so that the contactors are separated from the silicon substrate; and

(i) mounting the contactors on a contact substrate having through holes to receive ends of the contactors therein so that at least one end of each of the contactors
15 functions as a contact pad for electric connection.

A further aspect of the present invention is another method of producing the contactors in a two dimensional manner on a silicon substrate and transferring the contactors to the adhesive tape and removing therefrom for establishing
20 a contact structure. The production method is comprised of the following steps of:

(a) forming a sacrificial layer on a surface of a substrate;

(b) forming a photoresist layer on the sacrificial layer
25 on the substrate;

(c) aligning a photo mask over the photoresist layer and exposing the photoresist layer with ultraviolet light through the photo mask, the photo mask including an image of the contactors;

30 (d) developing patterns of the image of the contactors on a surface of the photoresist layer;

(e) forming the a first layer of contactors made of electric conductive material in the patterns on the photoresist layer by an electroplating process;

35 (f) repeating the steps (b)-(e) above on the first layer of contactors to form a further layer of the contactors;

(g) stripping the photoresist layer off;

(h) placing an adhesive tape on the contactors so that upper surfaces of the contactors are attached to the adhesive tape;

5 (i) removing the sacrificial layer by an etching process so that the contactors on the adhesive tape are separated from the silicon substrate; and

(j) mounting the contactors on a contact substrate having through holes to receive therein ends of the

10 contactors wherein at least one end of each of the contactors function as a pad for electric connection.

A further aspect of the present invention is a method of producing the contactors in a two dimensional manner on a silicon substrate and transferring the contactors to the

15 adhesive tape. The production method is comprised of the following steps of:

(a) forming an conductive substrate made of electric conductive material on a dielectric substrate;

(b) forming a photoresist layer on the conductive

20 substrate;

(c) aligning a photo mask over the photoresist layer and exposing the photoresist layer with ultraviolet light through the photo mask, the photo mask including an image of the contactors;

25 (d) developing patterns of the image of the contactors on a surface of the photoresist layer;

(e) forming a first layer of contactors made of electric conductive material in the patterns on the photoresist layer by an electroplating process;

30 (f) repeating the steps (b) - (e) above on the first layer of contactors to form a further layer of the contactors;

(g) stripping off the photoresist layer;

(h) peeling the conductive substrate having contactors thereon from the dielectric substrate;

35 (i) placing an adhesive tape on the contactors on the conductive substrate so that upper surfaces of the contactors

adhere to the adhesive tape wherein adhesive strength between the contactors and the adhesive tape is larger than that between the contactors and the conductive substrate;

5 (j) peeling the conductive substrate so that the contactors on the adhesive tape are separated from the conductive substrate; and

(k) mounting the contactor on a contact substrate having a through hole in such a way the an end of the contactor is projected from an opposite surface of the contact substrate.

10 A further aspect of the second present invention is a probe contact assembly including the contact structure of the present invention. The probe contact assembly is formed of a contact substrate having a plurality of contactors mounted on a surface thereof, a probe card for mounting the contact
15 substrate and establishing electrical communication between the contactors and electrodes provided on the probe card, and a pin block having a plurality of contact pins to interface between the probe card and a semiconductor test system when the pin block is attached to the probe card.

20 The contactors are mounted vertically on a horizontal surface of the contact substrate where each of the contactors has a substantially straight shape. Each contactor is comprised of a tip portion which is protruded in a vertical direction to form a contact point, a base portion which is
25 inserted in a corresponding through hole on the contact substrate, and a spring portion provided between the tip portion and the base portion which produces a resilient contact force when the contact structure is pressed against the contact target. The spring portion has a curved,
30 inclined, meander or zig-zag shape to exert the contact force, and an upper surface of the base portion is projected from the surface of the contact substrate and functions as a contact pad for electrical connection with an external component.

35 According to the present invention, the contact structure has a very high frequency bandwidth to meet the

test requirements of next generation semiconductor technology. Since the large number of contactors are produced at the same time on the substrate without involving manual handling, it is possible to achieve consistent
5 quality, high reliability and long life in the contact performance as well as low cost. Further, because the contactors are assembled on the same substrate material as that of the device under test, it is possible to compensate positional errors caused by temperature changes.

10 Further, according to the present invention, the production process is able to produce a large number of contactors in a horizontal direction on the silicon substrate by using relatively simple technique. Such contactors are removed from the substrate and mounted on a contact substrate
15 in a vertical direction. The contact structure produced by the present invention are low cost and high efficiency and have high mechanical strength and reliability.

Brief Description of the Drawings

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

Figure 2 is a diagram showing an example of more detailed structure for connecting the test head of the semiconductor test system to the substrate handler through an
25 interface component.

Figure 3 is a bottom view showing an example of the probe card having an epoxy ring for mounting a plurality of probe contactors (needles or cantilevers) in the conventional technology.

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

Figure 5 is a schematic diagram showing an example of contact structure of the present invention using contactors produced in a horizontal direction on a silicon substrate and
35 vertically mounted on a contact substrate.

Figure 6 is a schematic diagram showing another example

of contact structure of the present invention using contactors produced in a horizontal direction on a silicon substrate and vertically mounted on a contact substrate.

5 Figure 7 is a schematic diagram showing a further example of contact structure of the present invention using contactors produced in a horizontal direction on a silicon substrate and vertically mounted on a contact substrate.

10 Figures 8A and 8B are schematic diagrams showing basic concepts of production method of the present invention in which a large number of contactors are formed on a planar surface of a silicon substrate and removed therefrom for later processes.

15 Figures 9A-9I are schematic diagrams showing examples of shape in contactors to be produced in the production process of the present invention and to be used in the contact structures of the present invention.

20 Figures 10A and 10B are diagrams showing a specific example of contactor of the present invention wherein Figure 10A is a front view of the contactor and Figure 10B is a side view of the contactor.

Figures 11A and 11B are diagrams showing another specific example of contactor of the present invention wherein Figure 11A is a front view of the contactor and Figure 11B is a side view of the contactor.

25 Figures 12A and 12B are diagrams showing a further specific example of contactor of the present invention wherein Figure 12A is a front view of the contactor and Figure 12B is a side view of the contactor.

30 Figures 13A and 13B are diagrams showing a further specific example of contactor of the present invention wherein Figure 13A is a front view of the contactor and Figure 13B is a side view of the contactor.

35 Figures 14A-14L are schematic diagrams showing an example of production process in the present invention for producing the contactors.

Figures 15A-15D are schematic diagrams showing another

example of production process in the present invention for producing the contactors.

5 Figures 16A-16N are schematic diagrams showing an example of process for producing contact structures in the horizontal surface of a substrate and transferring the contactors to an intermediate plate.

10 Figures 17A and 17B are schematic diagrams showing an example of pick and place mechanism and its process for picking the contactors and placing the same on a substrate such as a multi-layered silicon substrate to produce the contact structure of the present invention.

15 Figure 18 is a cross sectional view showing an example of probe contact assembly using the contact structure of the present invention as an interface between a semiconductor device under test and a test head of a semiconductor test system.

20 Figure 19 is a cross sectional view showing another example of probe contact assembly using the contact structure of the present invention as an interface between a semiconductor device under test and a test head of a semiconductor test system.

25 Figure 20 is a cross sectional view showing a further example of probe contact assembly using the contact structure of the present invention as an interface between a semiconductor device under test and a test head of a semiconductor test system.

30 Figure 21 is a schematic diagram showing an example of contact structure of the present invention having multi-layered standard silicon substrates and the contactors produced through the production process of the present invention.

35 Figure 22 is a perspective view showing a plurality of contact structures of the present invention each having a large number of contactors for assembling with one another to constitute a probe contact assembly of desired size.

 Figure 23 is a perspective view of the contact structure

of the present invention wherein plural contact substrates are connected with one another to establish a probe contact assembly with desired size, shape and number of contactors.

Detailed Description of the Preferred Embodiment

5 Figures 5-7 show examples of contact structure of the present invention. Each contact structure is configured by a contact substrate 20 and contactors 30. In the example of Figure 5, each contactor 30₁ extends substantially in a vertical direction and is formed of a base portion which is
10 connected to the contact substrate 20, a contact point which is preferably sharpened, and a meander shaped portion between the base portion and the contact point to function as a contact spring.

 In the example of Figure 6, each contactor 30₂ extends
15 substantially in the vertical direction and is formed of a base portion connected to the contact substrate 20, a contact point which is split into two or more points and preferably sharpened, and a zig-zag shaped portion between the base
20 portion and the contact point to function as a contact spring.

 In the example of Figure 7, each contactor 30₃ extends substantially in the vertical direction having a hook like shape and is formed of a base portion connected to the contact substrate 20, a contact point which is preferably
25 sharpened and is oriented in the vertical direction, and a curved portion between the base portion and the contact point to function as a contact spring.

 Each of the contactors 30 of Figures 5-7 produces contact pressure by a spring force derived mainly from the
30 horizontally curved portion, i.e., the meander shaped, zig-zag shaped or curved portion of the contactor, when the contact structure is pressed against contact pads 320 on a semiconductor wafer or printed circuit board 300. The contact pressure also creates a scrubbing effect at the tip
35 of the contactor (contact point) against the surface of contact pad 320. Such a scrubbing effect promotes an

improved contact performance when the contact point scrubs the oxide surface of the contact pad 320 to electrically contact the conductive material of the contact pad 320 under the oxide surface.

5 It should be noted that, the contactors 30₁, 30₂ and 30₃, can be interchangeably used and produced in accordance with the present invention, although the contact structure and its production method will be described with respect to only one or two of the contactors. Further, various other types of
10 contactors of the present invention will also be described later with reference to Figures 9-13, although the detailed description will be made only on limited types of contactors. Since the contactors of the present invention shown in Figures 5-7 and 9-13 are vertically mounted, rather than an
15 inclined fashion, on the horizontal surface of the contact substrate, a large number of contactors can be mounted within the limited space on the contact substrate.

 Figure 8A-8B show basic ideas of the present invention for producing such contactors. In the present invention, as
20 shown in Figure 8A, contactors 30 are produced on a planar surface of a substrate 40 which is a silicon substrate or other dielectric substrate in a horizontal direction, i.e., in a two dimensional manner. Then, the contactors 30 are removed from the substrate 40 to be mounted on the contact
25 substrate 20 of Figures 5-7 such as a printed circuit board, IC chip, or other contact mechanism in a vertical direction, i.e., in a three dimensional manner.

 In the example of Figure 8, the contactors 30 produced on a planar surface of a silicon or other dielectric
30 substrate 40 in a horizontal direction are transferred from the substrate 40 to an adhesive member 90, such as an adhesive tape, adhesive film or adhesive plate (hereafter collectively "adhesive tape" or "intermediate plate"). The contactors 30 on the adhesive tape are removed therefrom to
35 be mounted on a contact substrate 20 of Figures 5-7 such as a printed circuit board, IC chip, or other contact mechanism

in a vertical direction, i.e., in a three dimensional manner with use of a pick and place mechanism.

Figures 9A-9I show examples of various shapes of the contactors of the present invention to be mounted on the contact substrate in the manner shown in Figures 5-7. The examples of Figures 9A-9E have a flat base at one end to be protruded from the upper surface of the contact substrate 20 of Figures 5-7 and a contact tip at the other end. The contact tips of Figures 9A-9E have various shapes to contact with the surface of the contact target with low contact resistance. The example of Figure 9D has a spring like contact tip to achieve elasticity in the vertical direction. In forming a probe assembly, a conductive elastomer may be preferably used to produce a resilient spring force or elasticity in the vertical direction when the contactors contact the contact targets as will be described with reference to Figure 19.

The examples of Figures 9F-9I have a triangle top on the base portion to be projected from the upper surface of the contact substrate 20 of Figures 5-7. Each of the contactors of Figures 9A-9I are substantially straight as a whole and is mounted substantially vertically relative to the horizontal surface of the contact substrate. Similar to the examples of Figures 9A-9E, the contact tips of Figures 9F-9I have various shapes to contact with the surface of the contact target with low contact resistance. In forming a probe assembly, a conductive elastomer may be preferably used to produce a resilient spring force or elasticity in the vertical direction when the contactors contact the contact targets as will be described with reference to Figure 19.

Figures 10A and 10B show a specific example of contactor of the present invention wherein Figure 10A is a front view and Figure 10B is a side view thereof. The contactor of Figure 10 has a base portion with an upper end to be protruded from the upper surface of the contact substrate 20 of Figures 5-7 when mounted thereon, a contact portion at a

lower end having a contact point to contact the surface of the contact target, and a straight body portion between the base portion and the contact portion to be inserted in the contact substrate 20 of Figures 5-7. The contact portion is meander or zig-zag shaped to function as a spring when pressed against the contact target.

In the front view of Figure 10A, the base portion is extended in the right and left direction. In the side view of Figure 10B, the contact portion is sized thinner than the straight body portion or the base portion to be easily deformed, thereby exerting the resilient spring force when pressed against the contact target. Because of the two different thickness, i.e, the thinner area for the contact portion and the thicker area for the body and base portions, conductive materials are deposited two or more times to form two layers or more in the production process of the contactor. An example of sizes in the contactor of Figure 10 is: $a=1050.00\mu\text{m}$, $b=330.00\mu\text{m}$, $c=200.00\mu\text{m}$, $d=50.00\mu\text{m}$, $e=150.00\mu\text{m}$, $f=20.00\mu\text{m}$, $g=50.00\mu\text{m}$, and $h=20.00\mu\text{m}$.

Figures 11A and 11B are diagrams showing another specific example of contactor of the present invention wherein Figure 11A is a front view and Figure 11B is a side view thereof. The contactor of Figure 11 has a base portion with an upper end to be protruded from the upper surface of the contact substrate 20 of Figures 5-7 when mounted thereon, a contact portion at a lower end having a contact point to contact the surface of the contact target, and a straight body portion between the base portion and the contact portion to be inserted in the contact substrate 20 of Figures 5-7. The contact portion is meander or zig-zag shaped to function as a spring when pressed against the contact target.

In the side view of Figure 11B, the base portion has the largest thickness to increase a top area to contact with external components such as a probe card shown in Figures 18-20. Also in the side view of Figure 11B, the contact portion is sized thinner than the straight body portion or the base

portion to be easily deformed, thereby exerting the spring force when pressed against the contact target. Because involving the three different thickness, i.e, first thickness for the contact portion, second thickness for the body portion, and third thickness for the base portions, conductive materials may be deposited three times or more in the production process of the contactor. An example of sizes in the contactor of Figure 11 is: $a=1000.00\mu\text{m}$, $b=1,330.00\mu\text{m}$, $c=200.00\mu\text{m}$, $d=50.00\mu\text{m}$, $f=20.00\mu\text{m}$, $g=80.00\mu\text{m}$, $h=20.00\mu\text{m}$, and $i=50.00\mu\text{m}$.

Figures 12A and 12B are diagrams showing a further specific example of contactor of the present invention wherein Figure 12A is a front view and Figure 12B is a side view thereof. The contactor of Figure 12 has a base portion with an upper end to be protruded from the upper surface of the contact substrate 20 of Figures 5-7 when mounted thereon, a contact portion at a lower end having a contact point to contact the surface of the contact target, and a straight body portion between the base portion and the contact portion to be inserted in the contact substrate 20 of Figures 5-7. The contact portion is meander or zig-zag shaped to function as a spring when pressed against the contact target.

In the front view of Figure 12A, the base portion is extended in the right and left direction. In the side view of Figure 12B, the contact portion is sized thinner than the straight body portion or the base portion to be easily deformed, thereby exerting the resilient spring force when pressed against the contact target. The thickness of the contact portion of this example is much smaller than that of the examples of Figures 10 and 11. Because involving the two different thickness, i.e, conductive materials can be deposited two or more times to form two or more layers of conductive material in the production process of the contactor. An example of sizes in the contactor of Figure 12 is: $a=1050.00\mu\text{m}$, $b=330.00\mu\text{m}$, $c=200.00\mu\text{m}$, $d=50.00\mu\text{m}$, $e=150.00\mu\text{m}$, $f=10.00\mu\text{m}$, $g=50.00\mu\text{m}$, and $h=10.00\mu\text{m}$.

Figures 13A and 13B are diagrams showing a further specific example of contactor of the present invention wherein Figure 13A is a front view and Figure 13B is a side view thereof. The contactor of Figure 13 has a base portion with an upper end to be protruded from the upper surface of the contact substrate 20 of Figures 5-7 when mounted thereon, a contact portion at a lower end to contact the surface of the contact target, and a straight body portion between the base portion and the contact portion to be inserted in the contact substrate 20 of Figures 5-7. The contact portion has a unique shape with two loop like springs to exert a contact force when pressed against the contact target.

In the front view of Figure 13A, the base portion is extended in the right and left direction. In the side view of Figure 13B, the contact portion is sized thinner than the body portion or the base portion to be easily deformed, thereby exerting the resilient spring force when pressed against the contact target. Because involving the two different thickness, the conductive materials may be deposited two or more times to establish the different thickness in the production process of the contactor. An example of sizes in the contactor of Figure 13 is: $a=1050.00\mu\text{m}$, $b=500.00\mu\text{m}$, $c=200.00\mu\text{m}$, $d=50.00\mu\text{m}$, $e=150.00\mu\text{m}$, $f=20.00\mu\text{m}$, $g=50.00\mu\text{m}$, and $h=20.00\mu\text{m}$.

Figures 14A-14L are schematic diagrams showing an example of production process for producing the contactor 30 (such as contactor 30, of Figure 7) of the present invention. In Figure 14A, a sacrificial layer 42 is formed on a substrate 40 which is typically a silicon substrate. Other dielectric substrate is also feasible such as a glass substrate and a ceramic substrate. The sacrificial layer 42 is made, for example, of silicon dioxide (SiO_2) through a deposition process such as a chemical vapor deposition (CVD). The sacrificial layer 42 is to separate contactors 30 from the silicon substrate in the later stage of the production process.

An adhesion promoter layer 44 is formed on the sacrificial layer 42 as shown in Figure 14B through, for example, an evaporation process. An example of material for the adhesion promoter layer 44 includes chromium (Cr) and titanium (Ti) with a thickness of about 200-1,000 angstrom, for example. The adhesion promoter layer 44 is to facilitate the adhesion of conductive layer 46 of Figure 14C on the silicon substrate 40. The conductive layer 46 is made, for example, of copper (Cu) or nickel (Ni), with a thickness of about 1,000-5,000 angstrom, for example. The conductive layer 46 is to establish electrical conductivity for an electroplating process in the later stage.

In the next process, a photoresist layer 48 is formed on the conductive layer 46 over which a photo mask 50 is precisely aligned to be exposed with ultraviolet (UV) light as shown in Figure 14D. The photo mask 50 shows a two dimensional image of the contactor 30 which will be developed on the photoresist layer 48. As is well known in the art, positive as well as negative photoresist can be used for this purpose. If a positive acting resist is used, the photoresist covered by the opaque portions of the mask 50 hardens (cure) after the exposure. Examples of photoresist material include Novolak (M-Cresol-formaldehyde), PMMA (Poly Methyl Methacrylate), SU-8 and photo sensitive polyimide. In the development process, the exposed part of the resist can be dissolved and washed away, leaving a photoresist layer 48 of Figure 14E having an opening or pattern "A". Thus, the top view of Figures 14F shows the pattern or opening "A" on the photoresist layer 48 having the image (shape) of the contactor 30.

In the photolithography process in the foregoing, instead of the UV light, it is also possible to expose the photoresist layer 48 with an electron beam or X-rays as is known in the art. Further, it is also possible to directly write the image of the contact structure on the photoresist layer 48 by exposing the photoresist 48 with a direct write

electron beam, X-ray or light source (laser).

The contactor material such as copper (Cu), nickel (Ni), aluminum (Al), rhodium (Rh), palladium (Pd), tungsten (W) or other metal, nickel-cobalt (NiCo) or other alloy combinations thereof is deposited (electroplated) in the pattern "A" of the photoresist layer 48 to form the contactor 30 as shown in Figure 14G. Preferably, a contact material which is different from that of the conductive layer 46 should be used to differentiate etching characteristics from one another as will be described later. The over plated portion of the contactor 30 in Figure 14G is removed in the grinding (planarizing) process of Figure 14H.

The above noted process is repeated for producing the contactors such as shown in Figures 10-13 having different thickness by forming two or more conductive layers. Namely, after forming a first layer of the contactors (conductive material), if necessary, the processes of Figures 14D-14H are repeated to form a second layer or further layer on the first layer of the contactors.

In the next process, the photoresist layer 48 is removed in a resist stripping process as shown in Figure 14I. Typically, the resist layer 48 is removed by wet chemical processing. Other examples of stripping are acetone-based stripping and plasma O₂ stripping. In Figure 14J, the sacrificial layer 42 is etched away so that the contactor 30 is separated from the silicon substrate 40. Another etching process is conducted so that the adhesion promoter layer 44 and the conductive layer 46 are removed from the contactor 30 as shown in Figure 14K.

The etching condition can be selected to etch the layers 44 and 46 but not to etch the contactor 30. In other words, to etch the conductive layer 46 without etching the contactor 30, as noted above, the conductive material used for the contactor 30 must be different from the material of the conductive layer 46. Finally, the contactor 30 is separated from any other materials as shown in the perspective view of

Figure 14L. Although the production process in Figures 14A-14L shows only one contactor 30, in an actual production process, as shown in Figures 8A and 8B, a large number of contactors are produced at the same time.

5 Figures 15A-15D are schematic diagrams showing an example of production process for producing the contactors of the present invention. In the this example, an adhesive tape (intermediate plate) 90 is incorporated in the production process to transfer the contactors 30 from the silicon
10 substrate 40 to the adhesive tape 90. Figures 15A-15D only show the latter part of the production process in which the adhesive tape 90 is involved.

 Figure 15A shows a process which is equivalent to the process shown in Figure 14I where the photoresist layer 48 is
15 removed in the resist stripping process. Then, also in the process of Figure 15A, an adhesive tape (intermediate plate) 90 is placed on an upper surface of the contactor 30 so that the contactor 30 adheres to the adhesive tape 90. As noted
20 above with reference to Figure 8B, within the context of the present invention, the adhesive tape (intermediate plate) 90 includes other types of adhesive member, such as an adhesive film and adhesive plate, and the like. The adhesive tape 90
25 also includes any member which attracts the contactor 30 such as a magnetic plate or tape, an electrically charged plate or tape, and the like.

 In the process shown in Figure 15B, the sacrificial layer 42 is etched away so that the contactor 30 on the adhesive tape 90 is separated from the silicon substrate 40. Another etching process is conducted so that the adhesion
30 promoter layer 44 and the conductive layer 46 are removed from the contactor 30 as shown in Figure 15C.

 As noted above, in order to etch the conductive layer 46 without etching the contactor 30, the conductive material used for the contactor 30 must be different from the material
35 of the conductive layer. Although the production process in Figures 15A-15C shows only one contactor, in an actual

production process, a large number of contactors are produced at the same time. Thus, a large number of contactors 30 are transferred to the adhesive tape 90 and separated from the silicon substrate and other materials as shown in the top view of Figure 15D.

Figures 16A-16N are schematic diagrams showing a further example of production process for producing the contactor 30 where the contactors are transferred to the adhesive tape or intermediate plate. In Figure 16A, an electroplating seed (conductive) layer 342 is formed on a substrate 340 which is typically a silicon or glass substrate. The seed layer 342 is made, for example, of copper (Cu) or nickel (Ni), with a thickness of about 1,000-5,000 angstrom, for example. A chrome-inconel layer 344 is formed on the seed layer 342 as shown in Figure 16B through, for example, a sputtering process.

In the next process in Figure 16C, a conductive substrate 346 is formed on the chrome-inconel layer 344. The conductive substrate 346 is made, for example, of nickel-cobalt (NiCo) with a thickness of about 100-130 μ m. After passivating the conductive substrate 346, a photoresist layer 348 with a thickness of about 100-120 μ m is formed on the conductive substrate 346 in Figure 16D and a photo mask 350 is precisely aligned so that the photoresist layer 348 is exposed with ultraviolet (UV) light as shown in Figure 16E. The photo mask 350 shows a two dimensional image of the contactor 30 which will be developed on the surface of the photoresist layer 348.

In the development process, the exposed part of the resist can be dissolved and washed away, leaving a photoresist layer 348 of Figure 16F having a plating pattern transferred from the photo mask 350 having the image (shape) of the contactor 30 (such as contactor 30, of Figure 7). In the step of Figure 16G, contactor material is electroplated in the plating pattern on the photoresist layer 348 with a thickness of about 50-60 μ m. An example of the conductive

material is nickel-cobalt (NiCo). The nickel-cobalt contactor material will not strongly adhere to the conductive substrate 346 made of nickel-cobalt.

5 The above noted process may be repeated for producing the contactors such as shown in Figures 10-13 having different thickness by forming two or more conductive layers. Namely, after forming a first layer of the contactors, if necessary, the processes of Figures 16D-16G are repeated to form a second layer or further layer on the first layer of
10 the contactors.

In the next process, the photoresist layer 348 is removed in a resist stripping process as shown in Figure 16H. In Figure 16I, the conductive substrate 346 is peeled from the chrome-inconel layer 344 on the substrate 340. The
15 conductive substrate 346 is a thin substrate on which the contactors 30 are mounted with a relatively weak adhesive strength. The top view of the conductive substrate 346 having the contactors 30 is shown in Figure 16J.

Figure 16K shows a process in which an adhesive tape
20 (intermediate plate) 90 is placed on the upper surfaces of the contactors 30. The adhesive strength between the adhesive tape 90 and the contactors 30 is greater than that between the contactors 30 and the conductive substrate 346. Thus, when removing the adhesive tape 90 from the flexible
25 conductive substrate 346, the contactors 30 are transferred from the substrate 346 to the adhesive tape 90 as shown in Figure 16L. Figure 16M shows a top view of the adhesive tape 90 having the contactors 30 thereon and Figure 16N is a cross sectional view of the adhesive tape 90 having the contactors
30 30 thereon.

Figures 17A and 17B are schematic diagrams showing an example of process for picking the contactors 30 from the adhesive tape (intermediate plate) 90 and placing the contactors on the contact substrate 20. The pick and place
35 mechanism of Figures 17A and 17B is advantageously applied to the contactors produced by the production process of the

present invention described with reference to Figures 15A-15D and Figures 16A-16N involving the adhesive tape. Figure 17A is a front view of the pick and place mechanism 80 showing the first half process of the pick and place operation. Figure 17B is a front view of the pick and place mechanism 80 showing the second half process of the pick and place operation.

In this example, the pick and place mechanism 80 is comprised of a transfer mechanism 84 to pick and place the contactors 30, mobile arms 86 and 87 to allow movements of the transfer mechanism 84 in X, Y and Z directions, tables 81 and 82 whose positions are adjustable in X, Y and Z directions, and a monitor camera 78 having, for example, a CCD image sensor therein. The transfer mechanism 84 includes a suction arm 85 that performs suction (pick operation) and suction release (place operation) operations for the contactors 30. The suction force is created, for example, by a negative pressure such as vacuum. The suction arm 85 rotates in a predetermined angle such as 90 degrees.

In operation, the adhesive tape 90 having the contactors 30 and the contact substrate 20 having the bonding locations 32 (or through holes) are positioned on the respective tables 81 and 82 on the pick and place mechanism 80. As shown in Figure 17A, the transfer mechanism 80 picks the contactor 30 from the adhesive tape 90 by suction force of the suction arm 85. After picking the contactor 30, the suction arm 85 rotates by 90 degrees, for example, as shown in Figure 17B. Thus, the orientation of the contactor 30 is changed from the horizontal direction to the vertical direction. This orientation mechanism is just an example, and a person skilled in the art knows that there are many other ways to change the orientation of the contactors. The transfer mechanism 80 then places the contactor 30 on the bonding location 32 (or through holes) on the substrate 20. The contactor 30 is attached to the contact substrate 20 by being bonded to the surface or inserted in the through holes.

Figure 18 is a cross sectional view showing an example of total stack-up structure for forming a probe contact assembly using the contact structure of the present invention. The probe contact assembly is used as an interface between the device under test (DUT) and the test head such as shown in Figure 2. In this example, the probe contact assembly includes a probe card (routing board) 260, and a pogo-pin block (frog ring) 130 provided over the contact structure in the order shown in Figure 18. The contact structure is configured by a plurality of contactors 30₁ mounted on the contact substrate 20. A base portion 35 of each of the contactors is projected at an upper surface of the contact substrate 20 as a contact pad.

The probe card 260, pogo-pin block 130 and contact structure are mechanically as well as electronically connected with one another, thereby forming a probe contact assembly. Thus, electrical paths are created from the contact point of the contactors 30₁ to the test head 100 through the cables 124 and performance board 120 (Figure 2). Thus, when the semiconductor wafer 300 and the probe contact assembly are pressed with each other, electrical communication will be established between the DUT (contact pads 320 on the wafer 300) and the test system.

The pogo-pin block (frog ring) 130 is equivalent to the one shown in Figure 2 having a large number of pogo-pins to interface between the probe card 260 and the performance board 120. At upper ends of the pogo-pins, cables 124 such as coaxial cables are connected to transmit signals to printed circuit boards (pin electronics cards) 150 in the test head 100 in Figure 2 through the performance board 120. The probe card 260 has a large number of electrodes 262 and 265 on the upper and lower surfaces thereof. When assembled, the base portions 35 of the contactors 30 contact the electrodes 262. The electrodes 262 and 265 are connected through interconnect traces 263 to fan-out the pitch of the contact structure to meet the pitch of the pogo-pins in the

pogo-pin block 130.

Figure 19 is a cross sectional view showing another example of probe contact assembly using the contact structure of the present invention. The probe contact assembly is used as an interface between the device under test (DUT) and the test head such as shown in Figure 2. In this example, the probe contact assembly includes a conductive elastomer 250, a probe card 260, and a pogo-pin block (frog ring) 130 provided over the contact structure.

The conductive elastomer 250 is provided between the contact structure and the probe card 260. When assembled, the base portions 35 of the contactors 30 contact the conductive elastomer 250. The conductive elastomer 250 is to ensure electrical communications between the base portions 35 of the contactors 30, and the electrodes 262 of the probe card 260 by compensating irregularity of flatness or vertical gaps therebetween. The conductive elastomer 250 is an elastic sheet having a large number of conductive wires in a vertical direction. For example, the conductive elastomer 250 is comprised of a silicon rubber sheet and a multiple rows of metal filaments. The metal filaments (wires) are provided in the vertical direction of Figure 19, i.e., orthogonal to the horizontal sheet of the conductive elastomer 250. An example of pitch between the metal filaments is 0.05mm or less and thickness of the silicon rubber sheet is about 0.2mm. Such a conductive elastomer is produced by Shin-Etsu Polymer Co. Ltd, Japan, and available in the market.

Figure 20 is a cross sectional view showing a further example of probe contact assembly using the contact structure of the present invention. The probe contact assembly is basically the same as that of Figure 19 except for the contact structure which is formed of a plurality of contact structure (substrate) blocks. Further, the contact substrate block is formed of a plurality of standard substrates stacked together. For example, the contact structure of Figure 20 is

configured by two contact structure (substrate) blocks 20₁ and 20₂, each having three silicon standard substrates 22₁, 22₂ and 22₃.

Although only one of them is shown, a plurality of
5 contactors 30₁ are attached to the contact substrate 20 in a manner that an end of each contactor 30₁ is inserted in a through hole 25 (Figure 21) of the substrate 22. Typically, the contact substrate 22 is made of silicon wafer, however, other dielectric materials such as ceramic, glass, polyimide
10 and the like are also feasible. In the preferred embodiment, the contact substrate 22 is a multi-layered substrate having multiple standard silicon wafers such as three wafers 22₁, 22₂ and 22₃, which are stacked and bonded to one another. The major reason of using the multiple silicon wafers is to
15 attain a sufficient thickness of the contact substrate without increasing tolerance in mechanical dimensions. Thus, the number of silicon wafers can be selected freely such as one or more depending on the specific requirements in the design. The standard silicon wafers have the same thickness
20 but different outer shape to create engagement mechanism such as teeth and recesses as shown in Figure 23.

Figure 21 is a cross sectional view showing details of contact structure of the present invention incorporated in the probe contact assembly of Figure 20. The contactor 30₁,
25 having the meander or hook shape is attached to the contact substrate 20 in a manner that an end of the contactor 30₁ is inserted in a through hole 25. In this example, the contact substrate 20 is a multi-layered substrate having three standard silicon wafers 22₁, 22₂ and 22₃, which are stacked and
30 fusion bonded to one another. An example of thickness of each of the silicon wafers 22₁-22₃ is about 0.5mm. The end of the contactor 30₁ is projected from the bottom surface of the contact substrate 20 for forming the contact pad 35. As an example, the size of the contact pad 35 is 0.5mm in its
35 width. The contactor 30₁ has a flange like portion 34 to be fitted with a step provided in the through hole 25. A

contact point at the tip of the contactor 30₁ is preferably sharpened to promote the scrubbing effect on the surface of the contact target.

5 The process of forming three layered substrate 20 and through holes thereon shown in Figure 21 is briefly explained in the following. First, the second wafer 22₂ and the third wafer 22₃ are directly bonded through, for example, silicon fusion bonding. Then the wafers 22₂ and 22₃ are polished both front and back, and through holes are created therethrough by
10 an etching process. Such a deep trench etching is achieved, for example, by reactive ion etching using a reactive gas plasma. As shown in Figure 21, the size of the through holes on the second and third wafers 22₂ and 22₃ must be smaller than the flange like portion 34 of the contactor 30 to form
15 the steps in the through holes.

Then, the first wafer 22₁ is polished its front and back surfaces and through holes 25 are created therethrough by the deep trench etching noted above. The size of the through holes of the first wafer 22₁ is larger than that of the
20 second and third wafers 22₂ and 22₃ to receive the flange like portion 34 of the contactor 30 as noted above. The first wafer 22₁ is aligned and fusion bonded to the second and third wafers 22₂ and 22₃. For insulation, silicon oxide layers of, for example, at least one micrometer is preferably
25 grown on all of the exposed surfaces of the contact substrate produced in this manner. Then, the contactor 30 is inserted in the through holes 25 and fixed therein by an adhesive if necessary.

Figure 22 is a perspective view showing an example of
30 contact structure (substrate) blocks of the present invention each having a large number of contactors 30 produced through the process shown in Figures 8A and 8B. This example shows a plurality of contact structure blocks 20 to be assembled with one another to build a contact structure of desired size
35 and desired number of contactors. In Figure 22, although each contact structure block includes contactors assembled in

a single line, a contact structure block of the present invention may include contactors aligned in two or more lines, i.e., a matrix manner.

As noted above, one of the features of the present invention is the capability of combining a plurality of contact structure blocks 20 to create a contact structure (probe contact assembly) of increased overall size and number of contactors. In the example of Figure 22, four contact structures 20 are prepared to be connected with one another. Although not shown in the example of Figure 22, each contact substrate 22 has connection or engagement mechanism such as teeth at the outer edges thereof.

Figure 23 is a perspective view of the contact structure formed by a plurality of contact structure blocks of the present invention. In this example, five contact substrates are connected with one another to create a contact structure having an overall size which is an integer multiple of the size of the contact structure block. For simplicity of illustration, the contactors are not shown on the contact substrates 22. By combining the contact substrates 22 in this manner, a contact assembly of desired size such as equivalent to the size of a twelve-inch semiconductor wafer can be established.

In this example, the right and left edges of the contact substrate are provided with engagement teeth 55 and recesses 65. The size of the tooth 55 and recess 65 is the same in the right and left edges, however, the position of the tooth 55 and recess 65 is shifted by one unit. Thus, the left edge of one contact substrate 22 fits with the right edge of the another contact substrate 22. Although not shown in Figure 23, a projection is provided at a distal end of the contact substrate 22 to fit in a groove 70 at a proximal end of another contact substrate 22. Instead of using the projections and grooves, it is also possible to use the teeth and recesses such as in the right and left edges described above. The contactors 30 will be mounted on the contact

substrates 22 in the manner shown in Figures 22 in the through holes 25.

According to the present invention, the contact structure has a very high frequency bandwidth to meet the test requirements of next generation semiconductor technology. Since the large number of contactors are produced at the same time on the substrate without involving manual handling, it is possible to achieve consistent quality, high reliability and long life in the contact performance. Further, because the contactors are assembled on the same substrate material as that of the device under test, it is possible to compensate positional errors caused by temperature changes. Further, it is possible to produce a large number of contactors in a horizontal direction on the silicon substrate by using relatively simple technique. The contact structure produced by the present invention is low cost and high efficiency and has high mechanical strength and reliability. The contact structure produced by the method of the present invention are advantageously applied in testing a semiconductor wafer, packaged LSI, multi-chip module and the like including burn-in testing.

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 contact structure for establishing electrical connection with contact targets, comprising:

5 a contact substrate having through holes running through upper and lower surfaces; and

10 a plurality of contactors made of conductive material and mounted vertically on a horizontal surface of the contact substrate where each of the contactors has a substantially straight shape and is comprised of a tip portion which is oriented in a vertical direction to form a contact point, a base portion which is inserted in a corresponding through hole on the contact substrate, and a spring portion provided between the tip portion and the base portion which produces a contact force when the contact structure is pressed against the contact target; and

15 wherein the spring portion has a curved, inclined, meander or zig-zag shape to exert the contact force, and an upper surface of the base portion is projected from the surface of the contact substrate and functions as a contact pad for electrical connection with an external component.

20 2. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate is formed of a single or a plurality of dielectric substrates bonded to one another and the through holes on the contact substrate are created through an etching process.

25 3. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein each of the contactors is provided with a flange like shape at the bottom portion thereof to be fitted in the through holes on the contact substrate.

30 4. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate is formed of a single



semiconductor wafer on which through holes are produced for mounting the contactors therethrough.

5 5. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate is formed of first and second semiconductor wafers which are bonded together on which through holes are produced for mounting the contactors therethrough.

10 6. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate is formed of three layers of semiconductor wafers which are bonded together on which through holes are produced for mounting the contactors therethrough.

15 7. A contact structure for establishing electrical connection with contact targets as defined in Claim 6, wherein the three layers of the contact substrate are formed of first, second and third semiconductor wafers, wherein the second and third semiconductor wafers are bonded and a second through hole is created therethrough by an etching process, and a first through hole which is larger than the second through hole is produced on the first semiconductor wafer, and wherein the first semiconductor wafer is aligned to match positions of the through holes and bonded to the second semiconductor wafer.

20 8. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contactors are produced on a planar surface of a flat substrate in a horizontal direction and removed from the flat substrate and mounted on the contact substrate in a vertical direction.

30 9. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate has an engagement mechanism at outer edges thereof for connecting other contact substrates at any desired edges to create a contactor assembly of



arbitrary size.

10. A contact structure for establishing electrical connection with contact targets as defined in Claim 9, wherein the engagement mechanism includes teeth and recesses provided at outer edges of the contact substrate in such a way that the engagement teeth and recesses in one edge fit with the engagement teeth and recesses in an opposite edge of other contact substrate, thereby assembling a plurality of contact substrates to establish the contactor assembly of desired size, shape and number of contactors.

11. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate is made of silicon.

12. A contact structure for establishing electrical connection with contact targets as defined in Claim 1, wherein the contact substrate is made of dielectric material including polyimide, ceramic and glass.

13. A method for producing a contact structure, comprising the following steps of:

(a) forming a sacrificial layer on a surface of a substrate;

(b) forming a photoresist layer on the sacrificial layer on the substrate;

(c) aligning a photo mask over the photoresist layer and exposing the photoresist layer with ultraviolet light through the photo mask, the photo mask including an image of contactors;

(d) developing patterns of the image of the contactors on a surface of the photoresist layer;

(e) forming a first layer of contactors made of electric conductive material in the patterns on the photoresist layer by an electroplating process;

(f) repeating the steps (b)-(e) above on the first layer of contactors to form a further layer of the contactors;

(g) stripping off the photoresist layer;



(h) removing the sacrificial layer and the conductive layer by an etching process so that the contactors are separated from the silicon substrate; and

5 (i) mounting the contactors on a contact substrate having through holes to receive ends of the contactors therein so that at least one end of each of the contactors functions as a contact pad for electric connection.

10 14. A method for producing a contact structure, comprising the following steps of:

(a) forming a sacrificial layer on a surface of a substrate;

(b) forming a photoresist layer on the sacrificial layer on the substrate;

15 (c) aligning a photo mask over the photoresist layer and exposing the photoresist layer with ultraviolet light through the photo mask, the photo mask including an image of the contactors;

20 (d) developing patterns of the image of the contactors on a surface of the photoresist layer;

(e) forming a first layer of contactors made of electric conductive material in the patterns on the photoresist layer by an electroplating process;

25 (f) repeating the steps (b)-(e) above on the first layer of contactors to form a second layer or a further layer of the contactors;

(g) stripping the photoresist layer;

30 (h) placing an adhesive tape on the contactors so that upper surfaces of the contactors adhere to the adhesive tape;

(i) removing the sacrificial layer and conductive layer by an etching process so that the contactors on the adhesive tape are separated from the silicon substrate; and

35 (j) mounting the contactors on a contact substrate having through holes to receive therein ends of the



contactors wherein at least one end of each of the contactors function as a pad for electric connection.

15. A method for producing a contact structure, comprising the following steps of:

- 5 (a) forming an conductive substrate made of electric conductive material on a dielectric substrate;
- (b) forming a photoresist layer on the conductive substrate;
- (c) aligning a photo mask over the photoresist layer and
10 exposing the photoresist layer with ultraviolet light through the photo mask, the photo mask including an image of the contactors;
- (d) developing patterns of the image of the contactors on a surface of the photoresist layer;
- 15 (e) forming a first layer of contactors made of electric conductive material in the patterns on the photoresist layer by an electroplating process;
- (f) repeating the steps (b) - (e) above on the first layer of contactors to form a second layer or a further layer of
20 the contactors;
- (g) stripping off the photoresist layer;
- (h) peeling the conductive substrate having contactors thereon from the dielectric substrate;
- (i) placing an adhesive tape on the contactors on the
25 conductive substrate so that upper surfaces of the contactors adhere to the adhesive tape wherein adhesive strength between the contactors and the adhesive tape is larger than that between the contactors and the conductive substrate;
- (j) peeling the conductive substrate so that the
30 contactors on the adhesive tape are separated from the conductive substrate; and
- (k) mounting the contactor on a contact substrate having a through hole in such a way the an end of the contactor is projected from an opposite surface of the contact substrate.

35 16. A probe contact assembly for establishing electrical connection with contact targets, comprising:



a contact substrate having a plurality of contactors mounted on a surface thereof;

a probe card for mounting the contact substrate and establishing electrical communication between the contactors and electrodes provided on the probe card; and

a pin block having a plurality of contact pins to interface between the probe card and a semiconductor test system when the pin block is attached to the probe card;

wherein the contactors are mounted vertically on a horizontal surface of the contact surface where each of the contactors has a substantially straight shape and is comprised of a tip portion which is protruded in a vertical direction to form a contact point, a base portion which is inserted in a corresponding through hole on the contact substrate, and a spring portion provided between the tip portion and the base portion which produces a contact force when the contact structure is pressed against the contact target; and

wherein the spring portion has a curved, inclined, meander or zig-zag shape to exert the contact force, and an upper surface of the base portion is projected from the surface of the contact substrate and functions as a contact pad for electrical connection with an external component.

17. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, further comprising a conductive elastomer provided between the contact substrate and the probe card for establishing electrical communication between the upper surface of the base portion of the contactor and the electrode of the probe card.

18. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein the contact substrate is formed of a single



or a plurality of semiconductor wafers bonded to one another and the through holes on the contact substrate are created through an etching process.

5 19. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein each of the contactors is provided with a flange like shape at the bottom portion thereof to be fitted in the through holes on the contact substrate.

10 20. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein the contact substrate is formed of a single semiconductor wafer on which through holes are produced for mounting the contactors therethrough.

15 21. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein the contact substrate is formed of first and second semiconductor wafers which are bonded together on which through holes are produced for mounting the contactors therethrough.

20 22. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein the contact substrate is formed of three layers of semiconductor wafers which are bonded together on which through holes are produced for mounting the contactors therethrough.

25 23. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 22, wherein the three layers of the contact substrate are formed of first, second and third semiconductor wafers, wherein the second and third semiconductor wafers are bonded and a second through hole is created therethrough by an etching process, and a first through hole which is larger than the second through hole is produced on the first semiconductor wafer, and wherein the first semiconductor
30 wafer is aligned to match positions of the through holes and
35 bonded to the second semiconductor wafer.



24. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein the contactors are produced on a planar surface of a flat substrate in a horizontal direction and removed from the flat substrate and mounted on the contact substrate in a vertical direction.

25. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 16, wherein the contact substrate has an engagement mechanism at outer edges thereof for connecting other contact substrates at any desired edges to create a contactor assembly of arbitrary size.

26. A probe contact assembly for establishing electrical connection with contact targets as defined in Claim 25, wherein the engagement mechanism includes teeth and recesses provided at outer edges of the contact substrate in such a way that the engagement teeth and recesses in one edge fit with the engagement teeth and recesses in an opposite edge of other contact substrate, thereby assembling a plurality of contact substrates to establish the contactor assembly of desired size, shape and number of contactors.

