TEST PROBE INTERFACE UNIT AND METHOD OF MANUFACTURING THE SAME

A test probe interface unit for connecting a test device to a semiconductor device, the unit comprising a dielectric baseplate, probes arranged in the same pattern as contact pads of the IC, contacts connecting the probe unit to the test device and conductors providing electrical connection between the probe and the contacts, the probes being formed by surface displacement of the dielectric baseplate. The proposed invention provides high density of probes and simplifies the production process.
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TEST PROBE INTERFACE UNIT AND METHOD OF MANUFACTURING

THE SAME

Technical field

The present invention relates generally to test probe interfaces for connecting testing assemblies to semiconductor devices and, more particularly, to a test probe interface comprising a contactor formed from a baseplate having probes arranged in a pattern matching the contact pad pattern of the integrated circuit.

The present invention is applicable in particular, though not exclusively, to test analysis of semiconductor devices using test probe assemblies, for example, to the test analysis of solid state memories, including semiconductor, ferro-electric, optical, holographic, molecular and crystalline atomic memories. The present invention is also applicable in connecting electrical circuits requiring high-precision multipositional (mechanical, capacitor, electrical or any other) contact durable in cyclic work.

Background of the invention

In the semiconductor industry, the fabrication of monocrystalline monolithic integrated circuits involves their formation on a single microelectronic substrate formed on a silicon wafer. The circuits are applied to the wafer by lithography (e.g. photolithography, electron, ion or x-ray lithography), each wafer containing an array of identical integrated circuits. The wafer is then sliced into dies, so that each die or chip carries a single semiconductor device. To assure that the various circuits are functioning properly, several testing operations are performed after each stage of fabrication, usually at wafer stage using a wafer probe, and in some processes also using a bare die probe, and again after packaging using a packaged die probe.

Each semiconductor wafer includes many dies, typically several hundred. A typical wafer probe card is such as that described in US 4,382,228. The conventional test interface unit includes an array of metal needles, or probes, in a fixed ring, which is mounted and electrically connected to a printed circuit board.
Each needle has to engage a respective contact pad on the device being tested. However, the test interface unit of this type does not meet a requirement encountered in semiconductor devices now being produced that have a multitude of contact pads. The main problem relating to this type of a probe unit is that the higher the density of contact pads of the device, the more difficult to achieve sufficient flexibility and strength of needles for maintaining them in a common plane without the needles touching each other, thereby rendering the unit defective. Besides, this type of probe unit is very complex in manufacturing and requires a special means for alignment.

Another problem is caused by that silicon chips are encapsulated in a plastic or ceramic package. However, the packaging of a chip is relatively costly and time consuming, the package greatly reduces the circuit density and degrades the electrical performance of the semiconductor device. The multiplicity of package types creates many handling problems in a live test. At present, there is a strong drive towards the use of a bare silicon die without any package. As a significant number of chips may be defective, it is extremely important to test the bare die before installing it in a working printed circuit board. Currently however, the bare die testing is difficult, especially due to difficulty of automatization of testing an unpackaged die which has no pins or leads.

A test head may require making contact with all, perhaps, 1000-1600 contact pads (from 4 to 200 contact pads in each die, depending on die type, testing 16, 32, 64, 128, 256 die simultaneously). Since all the contact pads on the wafer lie in a common plane and must be simultaneously connected in order to carry out testing, it is essential that all tips or points of the test probe interface lie in a plane parallel to the common plane of the wafer and are installed in the working positions corresponding to die contact pads.

A test interface unit capable of testing an unpackaged die has been disclosed in US 4,975,638. The known test assembly includes a rectangular frame and a contactor fabricated from a flexible film of dielectric material with planar portion which sags below the frame, the probes being formed in the planar
portion of the contactor. The test interface unit is adapted for connecting closely spaced contact pads arranged in a common plane, however only a limited number (typically, 4) of dies can be connected for testing simultaneously. Moreover, displacement in Z axis causes corresponding displacement in X and Y axis, thus resulting in relatively low arrangement accuracy of the test assembly. The elasticity of flexible film is non-uniform along the film length and decreases with time. The test assembly is very complex in manufacturing and has a relatively high cost.

A test probe interface which can be used at different stages, including integrated circuit level and, in case of enlarged probe points, at die or wafer level, as a functional circuit tester for standard testing purposes, has been proposed in US 5,103,557. The known high density probe unit comprises a baseplate made e.g. of a flexible silicon dioxide, a plurality of microscopic probe points arranged in the same pattern as contact pads of the device, contacts for connecting the probes to a testing device and conductors for providing electrical connection between the probes and the contacts. The contact points are the highest raised surface features having a hard metal core, a compressible portion, and a tip optionally plated with gold. The compressible probe points accommodate the height variances of the various dies, thus showing the independent height adjustment capability of each probe point which can be as much as 40% of its length and providing uniform pressure for all closely spaced probe points. However, the known test interface unit has a relatively high cost due to the complexity of its design and multistage character of the manufacturing process. Moreover, the maintaining of the probes in their working condition when in use is complex and requires repeating the manufacturing steps. Therefore, it is an acute necessity to create a relatively cheap and easily maintained probe interface unit for testing bare die before further processing.

Disclosure of Invention

It is an object of the present invention to provide a relatively cheap and easily-maintained high density test probe interface unit having a plurality of probe
points accurately arranged in a common plane in a pattern corresponding to a contact pad pattern of a semiconductor device and a simple method of manufacturing the probe unit. The proposed probe units may be grouped on a single base plate to test simultaneously a plurality of dies. A significant advantage of the invention is that the probe contacts due to manufacturing process all lie in a common plane and are arranged corresponding to contact pads of the semiconductor device with accuracy of up to ± 1 micron. The proposed invention avoids using complex means for maintaining the contacts in a common plane and reduces the time required for positioning the probe points in one plane in the course of testing procedure, thus increasing the test speed and total manufacturing yield. Also an object of the invention is to provide a test system using this probe interface unit.

The substance of the present invention is a test probe interface unit for connecting a test device to a semiconductor device having contact pads deployed in a predetermined pattern in a common plane, the probe unit comprising a base plate, a number of probe points corresponding to said contact pads of the device, contacts for connecting the probe unit to the test device and conductors providing electrical connection between the probe points and the contacts, wherein the probe points are base plate surface microcontacts, or microjuts, integral with the baseplate. The surface microcontacts are formed by local surface irradiation that is carried out in the locations corresponding to the contact pad pattern of the semiconductor device. The irradiation is carried out using an impulse energy source, for example, laser.

Surface microcontacts can also be fabricated alongside or as a part of an integrated circuit, or integrated circuits such as drivers or logic may be integrated with the probe. The advantages of this are high speed of testing due to low resistance and capacity of the test unit, low reflectivity, small dimensions of the test interface unit. The die may be chemically aligned.

The surface microcontacts, or microjuts, created by this process are tapered upwards, for example, they may be shaped in the form of a cone, a
truncated cone, a crater. The height is normally in the range from 1 micron to 100 microns, preferably from 15 microns to 25 microns, depending on the dimensions of the semiconductor device under test and the spacing between contact pads. The process of manufacturing the microcontacts is very precise and easily provides tolerances of ± 1 micron and can achieve even ± 0.1 or less. However, if necessary, the surface microcontact height may be additionally adjusted by cutting.

The center-to-center spacing between probe points of the proposed test probe interface typically shall be as much as twice the spacing between contact pads of the die, the latter being usually the same as the contact pad width. The center-to-center spacing may be, for example, 120 microns for pad width 60 microns, or any other depending on the pad width and spacing between pads of the semiconductor device to be tested. This spacing may be obtained by adjusting the center-to-center spacing of the irradiation zones and may be varied in the course of the manufacturing process. Usually, this spacing may also be calculated as not less than 2h, preferably not less than 4h, more preferably not less than 6h, where h is the desired contact height.

In the preferred embodiment of the present invention, the base plate of the probe unit is made of a dielectric material, the surface microcontacts, or juts, are formed of the same dielectric material subsequently coated with a conductive material, and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.

In another embodiment of the present invention, the base plate is made of a dielectric material coated with a conductive material, the surface microcontacts are formed of the same conductive material, interstices between the surface microcontacts are of a dielectric material, and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.

In still another embodiment of the present invention, the base plate is made of a dielectric material, the surface microcontacts are formed on springs mounted on the base plate; the springs are made of a flexible material capable of
surface displacement by irradiation, or made of flexible material covered with another material capable of surface displacement when irradiated; the microcontacts are plated with a conductive material; and the conductors are made in the form of conductive traces on the dielectric base plate.

In still another embodiment of the present invention, the base plate may be made of any suitable material capable of surface displacement when being irradiated, for example, metals such as titanium, nickel, semiconductors, such as silicon dioxide, germanium dioxide, and dielectric materials as mentioned above; the surface microcontacts may be formed of the same material; the surface of the baseplate after irradiation is coated with a dielectric material with subsequent coating of the surface microcontacts with a conductive material; and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.

In another embodiment of the present invention the probe unit comprises a baseplate in the form of an integrated circuit; surface microcontacts fabricated alongside or as a part of the integrated circuit; and conductors made in the form of conductive traces on the surface of the integrated circuit.

The conductive material may be selected from metals and alloys providing the overall electrical resistance of less than 0.1 Ohm. Typically, the contact material may be selected from a group including copper, aluminium, gold or non-oxidising metals, such as non-oxidising precious metals. In some cases, to reduce the cost of a conductive layer and to enhance the adhesion to the surface of the dielectric material, precious metals may be used as the upper coating layer only, the inner layer being formed from metals having high adhesion to dielectric materials. The inner layer metals may be selected from the group including, but not limited to, nickel, tungsten, chromium, titanium, palladium, berillium-copper alloy, or combinations thereof. The primer inner layer may be plated on the surface microcontacts formed on a dielectric base plate.

The dielectric material may be selected from the group including, but not limited to, silicon, silicon dioxide, silicon nitride, germanium, germanium dioxide,
indium antimonide, nickel phosphide, gallium alloys, as well as some metal compounds and plastics capable of surface displacement being subjected to irradiation. Dielectric materials having maximum difference between liquid and solid state density are preferable.

Another aspect of the present invention is a method of producing a test probe interface unit for connecting a test device to a die having contact pads deployed in a predetermined pattern in a common plane, the method comprising the steps of: providing a test base plate; forming probes corresponding to the said contact pads of the die; providing contacts for connecting the probe unit to the test device and conductors for electrical connection of the probe points and the contacts; wherein the probe points are formed by creating surface microcontacts on the base plate.

In the proposed method, the local surface irradiation is directed to the locations to be irradiated corresponding to the contact pad pattern of the die, thus providing high accuracy of the probe points arrangement. The locations on the base plate to be irradiated are determined by using conventional x-y tables providing the desired arrangement accuracy.

Any suitable energy source providing local surface irradiation may be used, in particular, impulse energy source, for example, laser beam of the neodimium laser. The form of the microcontacts may be varied greatly by means of at least one of the parameters selected from the irradiation power density, irradiation impulse duration and/or dimensions of the irradiation zone. In one of the preferred embodiments the impulse energy source is a neodimium laser having a wavelength of 1054nm, laser power density 7 kW/cm².

Another aspect of the present invention is a system for testing semiconductor devices having contact pads deployed in a common plane in a predetermined pattern, the system comprising a support for semiconductor devices; a test probe interface unit having probe points corresponding to the contact pads of the die; electrical interconnections between said probe points and contact pads for supplying diagnostic signals to the probe points; wherein the test
probe interface unit is the probe unit in accordance with the present invention. A method of testing semiconductor devices using this system has also been proposed.

Computer programs for implementing, emulating or simulating the operation functions of the system or of the unit or methods in accordance with the present invention when stored in electrically readable media has also been proposed.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, without loss of generality, to the accompanying drawings in which:

Fig.1 shows the block scheme of the test probe interface unit in accordance with the first embodiment of the present invention.

Fig.2 shows a cross section of the probe points formed on the base plate in accordance with the present invention.

Fig.3 shows the block scheme illustrating the method of producing the test probe interface unit in accordance with the proposed invention.

In Fig.4 scanning electron microphotographs are presented showing the probe points formed on the surface of a dielectric base plate made of monocristalline silicon.

Fig.5 shows the cone shapes and relationship between the center-to-center spacing and microcontact height in accordance with the present invention.

In Fig.6 scanning electron microphotographs are presented showing the probe tip shapes in accordance with the present invention.

Fig.7 is a schematic view of a test system using the test probe interface unit having cone microcontacts formed on the dielectric baseplate in accordance with the second embodiment of the present invention.

Fig.8 is a schematic view of a test system using the test probe interface unit having microcontacts formed on the springs in accordance with the third embodiment of the present invention.
The test probe interface unit in accordance with one of the embodiments of the present invention shown in Fig. 1 consists of a dielectric base plate 1, contacts 2, conductors 3 and probe points 4 coated with metal film 5. The dielectric base plate 1 provides electric isolation of the conductive parts 2, 3, 4 of the probe unit. The use of the silicon base plate provides maximal reduction of the thermal shift of the probe unit during test procedure in relation to the contact pads of the die which is also fixed on the silicon plate. Conductors 3 provide electrical connection of the probes 4 with contacts 2. The contacts 2 are used to connect the device to a test system. The side of the baseplate on which the contacts 2 are placed and their relative arrangement are defined taking into account actual design of a contact unit of the IC testing device to minimise the conductor resistance and provide reliable connection of the device to the IC testing device. The connection may be carried out mechanically, by bonding (welding) or soldering, mating contacts, pogo pins.

The cross-section of the probe points formed on the surface of the base plate is presented in Fig. 2. The probe points 4 are constituted by cone contacts 6 projecting on the surface of the base plate 1, being integer with the said base plate, and a thin film 5 of conductive material plated on the cone surface. The conductive film 5 may include two or more layers of conductive material.

The method of producing the probe points on the surface of the base plate is illustrated in Fig. 3. The irradiation of a power impulse laser 1 is focused on the surface of the base plate 2. The surface of the base plate is positioned substantially perpendicular in relation to the irradiation direction. The irradiation energy may be controlled by means of a calorimeter (not shown), on which a part of the basic laser beam may be separated by a separation plate. Filters may also be used for adjusting the energy power of the laser beam. On the first step, the base plate 2 is brought by means of an x-y table 3 in a starting position. Then, the surface of the base plate 2 is irradiated by a laser beam activated for a short time sufficient for melting down the base plate surface in the irradiated zone. Rapid heating and subsequent cooling of the silicon surface results in the formation of a
cone microjet which function as microcontact. After each irradiation shot, the base plate is moved mechanically by means of a conventional x-y table 3, for a relative distance corresponding to a center-to-center spacing between contact pads of the IC to be tested. Due to optical pumping asymmetry, the irradiation may be partially polarized in the movement direction. A multimode irradiation generator is used. The operations of positioning and irradiating are repeated. Microprocessor 4 programmed with the corresponding software and probe points coordinates 5 provides the automatic mode of operation.

The test probe interface unit according to the present invention is intended mainly for connecting a contact unit of a test device to contact pads of a die or wafer under test. The major test probe interface unit parameters that can affect wafer yields and require routine maintenance are mostly mechanical. These parameters include planarity, alignment, probe point diameter and probe point surface. (see T. M. Schnack, J. A. Allison "Probe Card Maintenance: A Key To Improving Wafer Test Performance", Probe Technology Corporation, Santa Clara, California). In addition, an important electrical parameter is contact resistance.

**Planarity**, or co-planarity, is defined as the maximum difference in heights h between all the probe points. Using a reference surface on the probe unit circuit board, the plane of the probe points should be parallel to this reference surface and the points should be all in the same plane or within a close tolerance. The industry standard specification for planarity on a new probe unit is 0.7 mils or approximately 18 microns. One of the main advantages of the present invention is that the process of the laser beam surface modification has significant reproducibility of the resulting cone microcontact heights. For cone contacts with height of 20 microns height deviations of less than 1 micron may be achieved.

The example structures are presented in Fig.4. Another advantage to be found is that the microcontact height may be easily varied by the laser power density, laser impulse duration or dimensions of the irradiation zone. For instance, when the surface of a monocrystalline silicon is treated by a neodium laser beam having wavelength of 1054 nm, power density of 7 kW/cm² and impulse duration
from 300 to 500 ns, contact heights from 15 to 30 microns may be produced.

The alignment of the probe unit is defined as the X,Y position of the probe point on the contact pad of the die to be tested, with respect to a known X,Y coordinate location (typically pad center). The alignment is a critical parameter, since misalignment of the probe can not only result in no electrical contact, but also cause damage to the passivation layer. The typical industry standard specification for alignment of a new probe unit is ± 12 microns from pad center for single die probe units or ± 18 microns for multidie probe units. An important advantage of the proposed invention is that the alignment procedure is built-in in the production method, as locations to be irradiated in the course of the probe growing process are defined by the X,Y coordinates of the contact pads of the device. As the proposed method uses irradiation by laser beam, the obtained probe units have very high probe point arrangement accuracy. This accuracy depends only on the accuracy of the base plate positioning system with respect to the laser axis. Available precision positioning systems provide high positioning accuracy with deviation of less than 0.01 microns in the range of 200×200 mm.

High resolution degree, i.e. the minimum center-to-center spacing between two adjacent probes, may be achieved in the present invention, the spacing may also be easily varied by varying the locations to be irradiated and dimensions of the irradiation zone. The high resolution degree provides the high density of the resulting probe unit.

Since the probes are “grown up” on the surface of the base plate from the material of the base plate itself, when a cone has grown, its peripheral zone becomes slightly dented, the dented area diameter being 3 diameters of the cone base in the case of a cone angle being approximately 90 degrees. Then, the minimum possible resolution, i.e. center-to-center spacing, is $\Delta L \approx 4h$, where $h$ is a microcontact height. When $h = 20$ micron, $\Delta L \approx 80$ micron (see Fig.5a). Preferably, to provide high reproducibility of the cone shape, i.e. to ensure each cone is formed fully independently from the other, the center-to-center spacing $\Delta L$
6h shall be chosen, where h is a microcontact height. In this case, when h = 20 micron, ΔL = 120 micron (see Fig.5b).

The probe shape and point diameter. The tip diameter of the probe point is largely determined by the size of the contact pad of the die, taking into account the overdrive and scrub size. Typical specifications for tip diameter, dependent upon pad size, range from 25-50 microns. In accordance with the present invention, for a cone probe having a base diameter of 100 microns, the tip diameter amounts approximately to 1-3 microns, or up to 10 microns after cutting, while for a cone probe of smaller base diameters the tip diameters are correspondingly smaller and may be greatly varied, being not critical for the proposed probe unit.

In addition to the tip diameter, the tip shape and surface also plays a significant role in the quality of the contact with the die. The tip shape of the cone probes produced by the proposed method is regular with the angle of approximately 90°, and may be flattened by cutting to a tip diameter of typically 10-15 microns. Fig. 6 shows the cone tip scanning electron microphotographs, the upper one being the tip view before cutting and the lower one after cutting. In case the probe points are made of the same dielectric material as the base plate, to provide the electrical contact, the tip surface is plated with a conductive material. Referring back to Fig. 2, the contact layer 5 on the surface of the probes, contacts 2 and conductors 3 are formed using known metal film coating methods. The film may be, for example, made of tungsten, chromium, titanium or copper, or a precious metal. A film thickness of up to 1 micron may be achieved by evaporation procedures, thicker films generally require galvanic methods.

To connect the die to the test probe interface, the probe interface is positioned facing the die contact pads and pressed by a special means with each other. The thickness of conductive layer 5 of the probe points typically exceed the height differences of the probe points in relation to the reference plane 1. Due to deformation to some extent of the conductive film 5, the reliable electrical contact is achieved between the probe points and the device under test. The resulting
contact resistance of a typical probe according to the present invention is less than 0.1 ohm. For comparison, the contact resistance of a conventional probe unit is about 1-2 ohms and may increase to 5-10 ohms under some circumstances, causing failures such as gross functional, speed reduction and continuity.

In another embodiment of the present invention, the proposed probe units may be grouped on a single base plate to test simultaneously several dies. The system shown in Fig. 7 comprises a common plate 1 on which a plurality of probe units is arranged in a predetermined pattern, preferably along the periphery of the base plate. Each probe unit consists of probes 2, base plate 3, conducting wires 4 and contactors 5 and is mounted on a common plate 1, optionally, by means of a special spring device (not shown) accommodating for differences in die under test heights. Contacts 7 connect the probes with a standard test device 6. Dies 8 under test by means of a conventional X,Y table 9 are positioned facing the respective probe units. The test system may be connected with the probe unit by means of spring loaded contacts. In case of considerable height difference of the tested dies, each die may be pressed against a corresponding group of the probes placed in one plane with special flexible or spring device (not shown). The spring device provides smooth load increase between the probes and die while connecting and maintaining the required contact force during the test.

In still another embodiment of the present invention, the proposed probes are formed on springs mounted on a base plate to accommodate height variances of different die under test. The system shown in Fig. 8 comprises a common plate 1 on which a plurality of probe units is arranged in a predetermined pattern. Each probe unit comprises probes 2 formed on springs 3, conducting wires 4 and contactors 5. Contacts 6 connect the probes with a standard test device 7. Dies 8 under test by means of a conventional X,Y table 9 are positioned facing the respective probe units. In case of considerable height difference of the tested dies, each die may be pressed against a corresponding group of the probes. The springs provides smooth load increase between the probes and die while connecting and maintaining the required contact force during the test.
Cyclic work parameters. As a probe unit is used, its mechanical and electrical properties begin to wear during normal wafer test operations. Typical industry standards call for a preventive maintenance procedure to be performed every 10,000 - 20,000 contacts. For the conventional probe unit with buckling beam probes, parameters such as positional accuracy, co-planarity of the probes, and critical dimensions subject to fast degradation with time and usage. The main advantage of the proposed probe unit is that positional accuracy does not change with time, while co-planarity and critical dimensions of the cone probes changes slightly. As a consequence, the proposed probe unit withstands about 25,000 - 30,000 touchdowns without special adjustment with gold, and 100,000 or more with tungsten. Moreover, an important advantage is the relatively low cost of a new probe unit production, that avoids expensive time-consuming repairing procedures involving the substitution of separate probes for those probe units that fail to pass the preventive maintenance program and rechecking the planarity and alignment of the repaired probe unit.

EXAMPLE 1.

A base plate made of monocristalline silicon having a thickness of 380 microns is irradiated by a neodium laser beam, wave length 1.054 microns, power density 4 kW/cm², impulse duration 0.3 ms, beam diameter on the surface 20 microns. The locations to be irradiated are positioned with center-to-center spacing of 45 microns. The resulting cone heights are 5 microns, cone base diameter is 10 microns, probe shape is rounded cone with curvature radius 1 micron. After plating by evaporation, a gold film having a thickness of 0.05 microns is obtained on the surface of the cone, the cone height being about 5 microns, cone base diameter being the same.

EXAMPLE 2.

A base plate made of a monocristalline silicon having a thickness of 500 microns is irradiated by a neodium laser beam, wave length 1.054 microns, power density 4 kW/cm², impulse duration 0.3 ms, beam diameter on the surface 80 microns. The locations to be irradiated are positioned with center-to-center
spacing of 100 microns. The resulting cone heights are 15 microns ± 0.5, cone base diameter is 36 microns, cone angle is nearly 90°. After cutting with conventional cutting tools, the probe shape is a truncated cone, cone height is 12 microns, tip radius is 3 microns. Then the cone surface is plated by evaporation, a gold film having a thickness of 0.2 micron being obtained, the cone height about 12 microns, cone base diameter being the same, cone tip diameter becoming 3 microns. Contact resistance of the probe unit is 0.03 ohm.

EXAMPLE 3.

Springs made of phosphorous bronze, having a diameter of 80 microns, are mounted on a base plate made of monocrystalline silicon having a thickness of 330 microns. The springs are irradiated by neodium laser beam, power density 25 mW/cm², impulse duration 50 ns, beam diameter on the surface is 20 microns. The springs are positioned with center-to-center spacing of 150 microns. The resulting cone heights are 20 microns. Then the cones are plated by pure gold, the film thickness being 0.05 microns, cone shape is rounded cone, tip diameter is 1 micron. Contact resistance is 0.02 ohm.

EXAMPLE 4.

A base plate made of monocrystalline silicon having a thickness of 380 microns is irradiated by neodium laser beam, wave length 1.054 microns, power density 7 kW/cm², impulse duration 0.5 ms, beam diameter on the surface 60 microns. The locations to be irradiated are positioned with center-to-center spacing of 80 microns. The resulting cone heights are 20 microns ± 0.5, cone base diameter is 40 microns, cone angle is nearly 87°. After plating by evaporation with titanium (film thickness is 0.1 micron) having good adhesion to silicon, a berillium copper film having a thickness of 0.5 micron is obtained on the surface of the cone. Then the cones are plated by pure gold, the film thickness being 0.05 microns, the resulting cone height becoming about 21 microns, cone base diameter being 30 microns, cone shape is rounded cone, tip diameter is 1 micron.
EXAMPLE 5.

On a common plate a plurality of base plates are mounted, each made of monocrystalline silicon having a thickness of 330 microns plated with titanium film having a thickness of 3 microns. The resulting structure is irradiated by a neodium laser beam, wave length 1,054 microns, power density 5 kW/cm², impulse duration 0.2 ms, beam diameter on the surface is 10 microns. The locations to be irradiated are positioned on the base plates with center-to-center spacing of 30 microns. The resulting cone heights are 7 microns ± 0.5, cone base diameter is 15 microns, cone tip diameter is 0.5 microns, tip radius is 0.5 micron. After plating by evaporation, a gold film having a thickness of 0.08 microns is obtained on the surface of the cone, the cone height is 7.1 microns, cone base diameter is 15 microns, cone tip diameter is 1 micron.

Thus, the proposed system provides fully automated processes of testing semiconductor devices including wafer testing and "bare die" testing, which may be easily maintained. The advantages of the present invention are evident for those skilled in the art, lying mainly in that it provides high density test probe interface unit having excellent arrangement accuracy and avoiding the use of complex repair procedures requiring highly skilled personnel with excellent hand-to-eye coordination for performing maintenance procedures under a microscope. The present invention also provides the simplified process of producing highly durable test probe interface unit.

It will be appreciated that the above are example embodiments only and that various modifications may be made to the embodiments described above within the scope of the present invention.
Claims

1. A test probe interface unit for connecting a test device to a semiconductor device having contact pads deployed in a predetermined pattern in a common plane, the probe unit comprising a base plate, a number of probe points corresponding to said contact pads of the semiconductor device, contacts for connecting the probe unit to the test device and conductors providing electrical connection between the probe points and the contacts, wherein the probe points are base plate surface microcontacts.

2. The probe unit as claimed in claim 1, wherein the surface microcontacts are formed by local surface irradiation.

3. The probe unit as claimed in claim 2, wherein the local surface irradiation is carried out in the locations corresponding to the contact pad pattern of the semiconductor device.

4. The probe unit as claimed in claim 2 or 3, wherein the local surface irradiation is carried out using an impulse energy source, for example, laser.

5. The probe unit as claimed in any one of claims 1-4, wherein the surface microcontacts are tapered upwards, for example, in the form selected from a cone, a truncated cone, a crater.

6. The probe unit as claimed in any one of claims 1-5, wherein the height h of the surface microcontacts is in the range from 1 micron to 100 microns, preferably from 15 microns to 25 microns.

7. The probe unit as claimed in any one of claims 1-6, wherein the surface microcontact height is adjusted by cutting.

8. The probe unit as claimed in any one of claims 1-7, wherein the center-to-center spacing between surface microcontacts is not less than 2h, preferably not less than 4h, more preferably not less than 6h, where h is a desired microcontact height.
9. The probe unit as claimed in any one of claims 1-8, *wherein* the base plate is made of a dielectric material, the surface microcontacts are formed from the same dielectric material subsequently coated with a conductive material, and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.

10. The probe unit as claimed in any one of claims 1-8, *wherein* the base plate is made of a dielectric material coated with a conductive material, the surface microcontacts are formed from the same conductive material, interstices between the surface microcontacts being from a dielectric material, and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.

11. The probe unit as claimed in claim 10, *wherein* the base plate is an integrated circuit chip, the irradiated locations are chip contact pads, the surface microcontacts are fabricated alongside or as a part of the integrated circuit, and conductors are made in the form of conductive traces on the surface of the integrated circuit.

12. The probe unit as claimed in any one of claims 1-8, *wherein* the base plate is made of a dielectric material, the surface microcontacts are formed on conductive elements made from a material capable of surface displacement by irradiation, or made from conductive material covered with another material capable of surface displacement by being subjected to irradiation.

13. The probe unit as claimed in any one of claims 1-8, *wherein* the base plate is made of a dielectric material, the surface microcontacts are formed on flexible elements mounted on the base plate, the flexible elements, for example, springs, are made of material capable of surface displacement when being irradiated, or made of material covered with another material capable of surface displacement when being irradiated, the microcontacts are plated with conductive material, and the conductors are made in the form of conductive traces on the dielectric base plate.
14. The probe unit as claimed in claim 13, wherein the springs are made from material selected from the group including, but not limited to, berillium copper, phosphorous bronze, phosphorous nickel, steel plated with silicon.

15. The probe unit as claimed in claim 13 or 14, wherein the springs are surface plated with non-oxidizing material by ion deposition, evaporation, chemical deposition.

16. The probe unit as claimed in any one of claims 9-15, wherein the conductive material is selected from the group including metals and alloys providing the overall electrical resistance of the unit less than 0.1 Ohm, such as nickel, tungsten, chromium, titanium, copper, palladium, aluminium and gold, berillium-copper alloy, or combinations thereof.

17. The probe unit as claimed in claim 9, wherein the surface microcontacts have at least two coating layers, the inner layer being nickel, and the outer layer being gold.

18. The probe unit as claimed in claim 9, wherein the surface microcontacts have at least two coating layers, the inner layer being berillium-copper alloy, and the outer layer being gold.

19. The probe unit as claimed in any one of claims 9-18, wherein the dielectric material is selected from a group including silicon, silicon dioxide, silicon nitride, germanium, germanium dioxide, gallium, indium antimonide, nickel phosphide.

20. The probe unit according to claims 1-19, wherein the form of the microcontacts is varied by means of at least one of the parameters selected from the radiation power density, wavelength, impulse duration and the area of the irradiated zone.

21. A method of producing a test probe interface unit for connecting a test device to a semiconductor device having contact pads deployed in a predetermined pattern in a common plane, comprising the following steps:
   - providing a test base plate,
   - forming probes corresponding to the said contact pads of the IC,
- providing contacts for connecting the probe unit to the test device and conductors for electrical connection of the probe points and the contacts, \textit{wherein} the probe points are formed by creating surface microcontacts on the base plate.

22. The method as claimed in claim 21, \textit{wherein} the step of creating the surface microcontacts is carried out by local surface irradiation.

23. The method as claimed in claim 22, \textit{wherein} the local surface irradiation is directed to the locations to be irradiated corresponding to the contact pad pattern of the semiconductor device.

24. The method as claimed in claim 22, \textit{wherein} the locations to be irradiated are determined by using x-y table.

25. The method as claimed in any one of claims 22-24, \textit{wherein} the local surface irradiation is carried out using an impulse energy source, such as laser.

26. The method as claimed in any one of claims 23-25, \textit{wherein} the center-to-center spacing between locations to be irradiated is not less than 2h, preferably not less than 4h, more preferably not less than 6h, where h is a desired microcontact height.

27. The method as claimed in any one of claims 22-26, \textit{wherein} the step of local surface irradiation is followed by the step of cutting for leveling the height of the surface microcontacts.

28. The method as claimed in any one of claims 21-27, \textit{wherein} the base plate is made of a dielectric material, the surface microcontacts are formed from the same dielectric material subsequently coated with a conductive material, and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.

29. The method as claimed in any one of claims 21-28, \textit{wherein} the base plate is made of a dielectric material coated with a conductive material, the surface microcontacts are formed from the same conductive material, interstices between the surface microcontacts being from the dielectric material, and the conductors are made in the form of conductive traces on the surface of the dielectric base plate.
30. The method as claimed in any one of claims 28-29, wherein the conductive material is selected from a group including metals and alloys providing a total electrical resistance of the probe unit less than 0.1 ohm, such as nickel, tungsten, chromium, titanium, copper, palladium, aluminium and gold, berillium-copper alloy, or combinations thereof.

31. The method as claimed in any one of claims 28-30, wherein the dielectric material is selected from the group including silicon, silicon dioxide, silicon nitride, germanium, germanium dioxide, gallium, indium antimonide, nickel phosphide.

32. The method as claimed in any one of claims 21-31, further comprising the step of adjusting microcontact dimensions by means of varying at least one of the parameters selected from the radiation power density, wavelength, impulse duration and/or dimensions of the irradiated zone.

33. The method as claimed in any one of claims 21-31, further comprising the step of adjusting microcontact dimensions by cutting.

34. The method as claimed in claim 24, wherein the impulse energy source is a neodium laser having wavelength of 1054 nm, laser power density 7 KW/cm², impulse duration 500 ns, irradiation zone is 80 micron.

35. A system for testing semiconductor devices having contact pads deployed in a common plane in a predetermined pattern, the system comprising a support for the devices, a plurality of test probe interface units each having probe points corresponding to the contact pads of the device, electrical interconnections between said probe points and contact pads for supplying diagnostic signals to the probe points, wherein the test probe interface unit is the probe unit according to claims 1-20.

36. A method of testing a semiconductor device using the system according to claim 35 or the test probe interface unit according to claims 1-20.
Fig. 3
THE CONE AFTER CUTTING

Fig. 6