

## PROBE CARD

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

5       The present invention relates generally to a semiconductor integrated circuit testing apparatus for testing semiconductor devices constructed of semiconductor integrated circuits, particularly to a part called "probe card" useful in a semiconductor integrated circuit testing apparatus for testing semiconductor  
10 integrated circuits in an unpackaged state (semiconductor integrated circuits prior to being packaged in a package) using apparatus known as wafer prober.

#### 2. Description of the Related Art

15       It is required to use an apparatus called wafer prober to test ICs to be shipped in the form of either wafer or chip (in an unpackaged state) (as will be referred to as "wafer IC" hereinafter) which is a semi-finished product among other semiconductor integrated circuits (as will be referred to as "IC" hereinafter). As will be described below, the  
20 wafer prober includes a probe card in the form of a ring having a plurality of probes mounted on its front surface which probes are adapted to be electrically contacted with a contactor member called flog ring attached to a performance board which is mounted on a tester head of an IC testing apparatus (as will be referred to as "IC  
25 tester" hereinafter).

      The wafer prober transports a wafer IC to be tested to a position where the terminals (leads) of the IC comes into contact with the

probes of the probe card. During the testing of the wafer IC to be tested, a test signal of a predetermined pattern is applied to the tester head of the IC testing apparatus from the tester proper (called main frame in the art concerned) accommodating mainly the electric  
5 circuitry of the IC tester. The test signal is in turn supplied to the probe card through the flog ring and the performance board of the tester head, and then applied to the wafer IC under test through the probes located of the probe card. The response signal from the wafer IC under test are provided to the IC tester proper via the reverse  
10 path opposite to that described just above. In this manner the testing is conducted on wafer ICs.

An example of the construction of the conventional IC tester of such type will be briefly described with reference to Figs. 13 and 14. The illustrated IC tester comprises two wafer probers 17, two rotary  
15 drives 130, each positioned adjacent the associated wafer prober 17, two tester heads 1, each pivotally or swingably mounted to the associated rotary drive 130, and a tester proper (main frame) 140 in the shape of a vertically elongated box.

While the main frame 140 comprises a cabinet, it is commonly  
20 called main frame in the art concerned, and will therefore be referred to as such hereinbelow. Accommodated within the main frame 140 is an IC tester section for generating a test signal, an address signal, etc. of a predetermined pattern to be applied to an IC under test in the wafer prober 10 and for receiving and processing a response signal  
25 from the IC under test to measure its electrical characteristics.

The wafer prober 17 has therein an automatic transport for transporting wafer ICs and is configured such that the terminals

(leads) of a wafer IC under test as brought in by the automatic transport are brought into electrical contact with the corresponding probes of the probe card located on the top surface of the wafer prober 17.

5       The tester head 1 is equipped with a flog ring 2 adapted to contact the probe card 3 located on the top surface of the wafer prober 17, and is normally in a position shown in solid lines in Fig. 13 where the flog ring 2 is in contact with the probe card 3. With the flog ring 2 in contact with the probe card 3, the flog ring 2 is directed  
10       downwardly and in electrical contact with the probe card 3. In this manner the wafer IC under test is electrically connected with the IC tester proper 140 through the probe card 3 in the wafer prober 17 to be subjected to testing for the electrical characteristics.

      The purpose of configuring the tester head 1 so as to be pivotable  
15       by the rotary drive 130 is as follows: During the testing of a wafer IC, the tester head 1 is maintained in the orientation shown in solid lines in Fig. 13 to maintain electrical contact between the IC tester proper 140 and the wafer prober 17. When the type of ICs being tested is to be varied, it may be required to replace the probe card 3 located on  
20       the top surface of the wafer prober 17 and the part of the flog ring 2 mounted to the tester head 1, depending on the variation in the number of the terminals, etc.. In order to facilitate the replacement of the probe card 3 and the part of the flog ring 2, the tester head 1 is pivotted by the rotary drive 30 through approximately 180° to be  
25       moved from above the top of the wafer prober 17 to the position shown in dotted lines in Fig. 13 and held in that position. This allows for easy access to the probe card 3 located on the top of the wafer

prober 17 for replacement. On the other hand, the tester head 1 itself is also 180° inverted to face the exposed surface of the part of the flog ring 2 upward for easy access for replacement. It is noted that the reference numeral 50 in Fig. 14 indicates a table on which a work station for administrating the tester proper 140 and the like are to be placed, the work station being located at one side of the tester proper 140.

Next, the conventional probe card 3 together with the associated the flog ring 2 will be described in details with reference to Figs. 7 and 8.

As noted above, a flog ring 2 is mounted to the bottom of the tester head 1 of the IC tester. The flog ring 2 comprises an electrically insulating disc 2c having a central through-opening 2a for visual observation formed through the center thereof, and a plurality of probe contact pins 2b of conductor arranged with predetermined angular intervals in a circular array around the peripheral portion of the insulating disc 2c and extending through the disc. These probe contact pins 2b are in electrical contact with corresponding contacts of the probe card 3.

The probe card 3 includes a disc-like printed circuit board 4 and a membrane 5 formed of a resilient circular insulating thin film, the printed circuit board 4 having on its front surface contacts 4b such as gold pads, for instance arranged with predetermined angular intervals in a circular array. These contacts 4b are to electrically contact the probe contact pins 2b of the flog ring 2 as noted above, and accordingly are formed on the board at positions corresponding to the probe contact pins 2b of the flog ring 2.

The printed circuit board 4 is formed in its center with a through-opening into which a transparent disc 12 termed mount is fitted from above the board. As will be readily appreciated from Figs. 8A and 8B, the mount 12 has a flange portion 12a engaged with the peripheral portion surrounding the through-opening of the printed circuit board 4 and a circular base portion depending below the flange portion 12a and fitted in the through-opening of the printed circuit board 4. The upper portion of the mount 12 extending upwardly beyond the flange portion 12a is of frusto-conical shape. The length of the extension of the base portion of the mount 12 is approximately equal to the thickness of the printed circuit board 4 such that the lower end face of the base portion is substantially flush with the bottom surface of the printed circuit board 4 when the base portion is fitted in the through-opening of the printed circuit board 4. The frusto-conical upper portion of the mount 12 extending upwardly beyond the flange portion 12a is engaged in the through-opening 2a of the flog ring 2.

The multiplicity of contacts 4b formed on the surface of the printed circuit board 4 are contacted with corresponding ones of a multiplicity of terminals (electrodes) formed on the reverse surface of the printed circuit board 4 via internal wiring (including conductor patterns and through-holes formed in the layers of the multi-layered board).

The mount 12 has formed therein a recess 8b extending from its reverse surface into the base portion. Housed in the recess 8b are a compression coil spring 7 and a loaded stem 8 falling under the urging force of the coil spring 7. The loaded stem 8 has a

hemispherical abutment portion 8a at its tip end (lower end ) larger than the diameter of the shank portion of the stem so that one end of the coil spring 7 surrounding the loaded stem 8 is engaged by the flat shoulder defined between the abutment portion 8a and the shank portion of the stem. In this regard the inner diameter of the coil spring 7 is sized to be larger than the diameter of the shank portion of the stem and smaller than the diameter of the abutment portion 8 of the stem at the shoulder. Consequently, the urging force (biasing force) of the coil spring 7 is exerted on the loaded stem 8 to normally bias the latter downwardly.

The hemispherical abutment portion 8a of the loaded stem 8 at its lower end is configured to engage with a spherical recess 9a formed in the front surface of a generally square pressure plate 9 at the center thereof which underlies the abutment portion 8a. When the recess 9a in the pressure plate 9 is engaged by the tip end of the abutment portion 8a, the pressure plate 9 is urged downwardly to urge the underlying membrane 5 downwardly. As will be described hereinafter, because of being formed of a sheet-like material having a resiliency, the membrane 5 is elastically stretched under the urging force to assume an archedly deflected shape in cross-section as shown in Fig. 8.

The membrane 5 in this example is an insulating, resilient circular member formed of polyimide film, and have a grounding conductor GND formed over the entire reverse surface thereof except a generally square area 5a surrounding the center O thereof as best seen in Fig. 11. In this example a copper foil is used for the grounding conductor GND. The reverse surface of the generally

square area (which will be referred to as central area) 5a devoid of the grounding conductor GND has a plurality of probes (needle-like bumps made of conductor, in this example) 5c extending downwardly therefrom. These probes 5c are arranged at positions  
5 corresponding to those of the terminals (leads) of a wafer IC since they are to be contacted with the terminals of the wafer IC when it has been brought to the test position over the top surface of the wafer prober.

The front surface of the membrane 5 is formed with a plurality of  
10 conductor patterns (electric wiring) 5b extending radially from the periphery of the membrane 5 to the central area 5a. Only one such conductor pattern is depicted in Fig. 11 for brevity of illustration. An outer end of each conductor pattern 5b functions as a terminal 5d which is connected through an elastic connector 6 with  
15 corresponding one of terminals formed in the reverse surface of the printed circuit board 4. The other end of each conductor pattern 5b extending in the central area 5a is electrically connected via a through-hole for example with corresponding one of the probes 5c on the reverse surface of the membrane.

20 As an alternative example of the membrane 5, the front surface of the membrane 5, as illustrated in Figs. 12A and 12B, may be formed around the peripheral portion with a plurality of pads (terminals) 5d which are connected through a connector 6 with corresponding terminals formed in the bottom face of the printed  
25 circuit board 4. Except this peripheral annular portion and the central area 5a, a grounding conductor GND is formed over the entire front surface of the membrane 5 while the front surface of the

membrane 5 is formed with a plurality of conductor patterns 5b extending radially from the peripheral portion of the membrane 5 to the central area 5a. Each of the pads 5d on the front surface of the membrane 5 may be connected via a through-hole with one end of  
5 corresponding one of the conductor patterns 5b on the reverse surface of the membrane 5 while the other end of the conductor pattern 5b may be electrically connected with the corresponding probe 5c provided in the central area 5a on the reverse surface of the membrane.

10 As shown in Fig. 9A, a plurality of probes 5c are provided in the central area 5a on the reverse surface of the membrane 5. As described above, the membrane 5 is elastically stretched as it is downwardly urged through the loaded stem 8 and the pressure plate 9 by the biasing force of the coil spring 7. This results in moving the  
15 probes 5c on the reverse surface of the membrane slightly outwardly in a radial direction with respect to the center O as indicated by arrows 16 in Fig. 9B.

Disposed under the printed circuit board 4 is a connector 6 in the form of a circular plate-like member formed of a resilient  
20 insulating material, the connector 6 being configured to establish electrical continuities across the thickness thereof at a plurality of locations in a mutually insulated manner. The connector 6 is formed in the center thereof with a through-opening larger in diameter than the through-opening of the printed circuit board 4 (approximately  
25 equal in diameter to the outer diameter of the flange portion of the mount 12).

While the connector 6 having electrical continuities across the

thickness thereof may be of various constructions, a connector 6 as illustrated in Figs. 10A and 10B may be used which comprises a circular sheet-like member 6c formed of a resilient insulating material such as insulating silicone rubber and a number of fine metal wires 6b extending through the thickness of the sheet-like member 6c in a mutually insulated manner. The length of the fine metal wires 6b is dimensioned such that they extend slightly beyond the front and reverse surfaces of the sheet-like member 6c. Upon being subjected to only a slight pressure, this connector 6 permits good electrical connection to be established between components disposed on the opposite side surfaces of the connector.

On the other hand, a first retainer 10 in the form of an insulating disc and a second retainer 11 also in the form of an insulating disc are disposed above and below, respectively of the printed circuit board 4. The first retainer 10 has formed in the center thereof a through-opening which is sized to fit over the flange portion 12a of the mount 12 while the second retainer 11 has formed in the center thereof a through-opening approximately equal in diameter to the through-opening of the connector 6. It is to be understood that the through-openings of the first and second retainers 10 and 11 and the connector 6 have diameters approximately equal to the outer diameter of the flange portion 12a of the mount 12.

In the illustrated example, the first retainer 10, the printed circuit board 4, the connector 6 and the membrane 5 have through-apertures 10a, 4c, 6a and 5e, respectively at vertically corresponding positions and the second retainer 11 has a threaded aperture 11a at a position vertically corresponding to that of the

through-aperture 10a of the first retainer 10. It will thus be appreciated that the first retainer 10, the printed circuit board 4, the connector 6, the membrane 5 and the second retainer 11 are assembled together with the coil spring 7 and the loaded stem 8 accommodated in the recess 8b of the mount 12 and with the abutment portion 8a at the tip end of the loaded stem 8 in engagement with the recess 9a (Fig. 7) of the pressure plate 9 as shown in Fig. 8 to constitute a probe card 3 by sandwiching the printed circuit board 4, the connector 6, the coil spring 7, the loaded stem 8, the pressure plate 9 and the membrane 5 between the first retainer 10 and the second retainer 11 with their respective through-apertures 10a, 4c, 6a and 5e vertically aligned with each other and by inserting a screw 15 through these through-apertures from above the first retainer 10 and threading and tightening it into the threaded aperture 11a of the second retainer 11.

It will be apparent that the skilled in the through-aperture 10a of the first retainer 10 may be a threaded aperture whereas the threaded aperture 11a of the second retainer 11 is replaced with a plain (non-threaded) through-aperture and that the membrane 5 is adhesively attached to the bottom surface of the second retainer 11, followed by inserting the screw 15 through the through-apertures of the components described above from below the bonded membrane 5 and threading into the threaded aperture of the first retainer 10 to assemble the components together. While only one screw 15 is shown in the drawings, two or more screws may be used as required.

The wafer prober 17 has formed through its upper wall 17w a through-opening 17a smaller in diameter than that of the printed

circuit board 4, but large enough not to interfere with the membrane 5 when the latter is deflected. As will be readily appreciated from Fig. 8B, the inner peripheral portion of the wafer prober 17 surrounding the through-opening 17a is formed with an annular recess (step) 17b which is cut down from the surface of the upper wall 17w to a depth approximately equal to the thickness of the printed circuit board 4 and which has a sufficient diameter to receive the printed circuit board 4.

The annular recess 17b has an alignment pin 17c extending therefrom for positioning the probe card 3 and is formed with a threaded hole 17d diametrically opposite the pin 17c. In this regard, the printed circuit board 4 is formed in its peripheral portion with a through-aperture 4d and a through-aperture 4e in diametrically opposed relation with each other and at positions corresponding to the pin 17c and the threaded hole 17d, respectively so as to be engageable with the pin 17c and receive the screw 19 threaded with the threaded hole 17d, respectively.

With this arrangement, the probe card 3 may be located in position with respect to the wafer prober 17 by fitting the through-aperture 4d of the printed circuit board 4 over the alignment pin 17c of the wafer prober 17 and fitting the printed circuit board 4 in the annular recess 17b of the wafer prober 17. In this condition, the screw 19 is inserted through the through-aperture 4e from above the printed circuit board 4 and threaded and tightened into the threaded hole 17d in the annular recess 17b to fasten the probe card 3 to the upper surface of the wafer prober 17.

Located below the through-opening 17a of the wafer prober 17 is

a stage 24 for placing a wafer IC 23 to be tested thereon. A wafer IC 23 to be tested is placed on the stage 24 with the terminals (pads) 23a on the front face of the wafer IC 23 contacted by the probes 5c provided on the undersurface of the membrane 5 of the probe card 3 to effect the testing of the wafer IC 23.

When the wafer IC 23 is to be tested, while observing the wafer IC 23, for example, as visually through the central openings and the transparent mount 12 from above the probe card 3 at the start of testing or at an appropriate point of time, the operator moves the stage 24 horizontally for adjustment to align the probes 5c with the pads 23a of the wafer IC 23 and then adjusts and fixes the horizontal (X and Y directions) positions. In case that wafer ICs are too small to be visually observed, the alignment is effected with the aid of suitable means such as a CCD camera.

Next, at the time of testing, the stage 24 is raised to align the pads 23a of the wafer IC 23 with the tips of the probes 5c. Further upward movement of the stage 24 by a short distance (which is referred to as  $\Delta H$ ) results in reducing the amount H of downward extension (see Fig. 8A) of the central area 5a of the membrane 5 by  $\Delta H$  so that the membrane 5 will elastically contract to slightly move the needle-like probes 5c back in the direction opposite to that indicated by the arrows 16 in Fig. 9. As a result, the faces of the pads 23a are slightly scrubbed (scratched) by the tips of the probes 5c (this action will be referred to as "scrubbing" herein) and thereby automatically refreshed. This serves to always maintain good electrical connection between the two (pads and probes).

Even if the entire probe card 3 is at a tilt with respect to the

surface of the wafer IC 23 and the loaded stem 8 is initially slightly offset from the Z axis perpendicular to the surface of the wafer IC 23, the abutment portion 8a (the curvature radius of which is referred to as R8) of the loaded stem 8 and the recess 9a (the curvature radius of which is referred to as R9) of the pressure plate 9 will not come out of engagement, since their spherical surfaces are flexibly engaged with each other under the spring force of the coil spring 7 (assuming that the curvature radii of the abutment portion 8a of the loaded stem 8 and the recess 9a of the pressure plate 9 are R8 and R9, respectively, R9 is equal to or slightly greater than R8). In this regard, the force of the loaded stem 8 acting on the pressure plate 9 has a component of force  $H_z$  in the Z-axis direction perpendicular to the surface of the wafer IC 23 much greater than a component of force  $F_h$  normal to the Z-axis direction, so that the loaded stem 8 is capable of urging the pressure plate 9 in the Z-axis direction with a sufficient force.

As discussed above, following the pads 23a of the wafer IC 23 being brought into abutment with the tips of the needle-like probes 5c, further upward movement of the stage 24 by a very short distance  $\Delta H$  to cause the probes 5c to effect the scrubbing action will make the probes 5c stand substantially upright on the wafer IC 23, and the square pressure plate 9 having approximately the same size as the central area 5a of the membrane 5 will pivot about the hemispherical abutment portion 8a of the loaded stem 8 until it assumes an attitude generally parallel to the surface of the wafer IC 23. That is, the pressure plate 9 assumes a generally horizontal attitude.

With the construction of the conventional probe card 3 as

described above, the thin film membrane 5 is pressed by the biasing force of the coil spring 7 and stretched by means of the pressure plate 9 to have an archedly extended shape in cross-section.

Consequently, as noted before with reference to Fig. 9, the positions of the probes 5c mounted to the reverse surface of the central area 5a of the membrane 5 are offset from the initial mounting positions in a radial direction with respect to the center O of the membrane 5 as indicated by the arrows 16. It should be noted, however, that there may be a considerable variation in the amount of offset between the various probes 5c, partly due to the influence of the conductor patterns 5b. Otherwise stated, the positions along the X and Y directions in the horizontal plane to which the various probes 5c have been moved are variable from probe to probe, so that the points at which some of the probes 5c abut with the corresponding pads 23a of the wafer IC 23 may be offset towards the outer edges of the pads 23a, possibly leading to lowering of reliability in electrical connection.

In addition, aged deterioration in flexibility of the membrane 5 and resiliency of the coil spring 7 causes a change in the extent H of extension of the membrane 5, which in turn may cause a change in the positions of the probes 5c along the X and Y directions, again possibly leading to lowering of reliability in electrical connection.

Moreover, the membrane 5, having elasticity, is stretchable while the loaded stem 8 is not fixed, so that even slight vibration and/or impact would sway the loaded stem 8, resulting in the pressure plate 9 in pivotal engagement with the loaded stem 8. Consequently, the positions of the probes 5c of the membrane 5 may

be varied, again possibly leading to lowering of reliability in electrical connection between the probes 5c and the pads 23a of the wafer IC 23.

On top of that, the variability from probe to probe as indicated  
5 above in the amount of offset (related to the amount of elongation of the membrane) of the probes 5c in a radial direction due to the stretch of the membrane 5 after the membrane 5 has been attached to the printed circuit board 4 is accompanied with variability from probe to probe in the amount of scrubbing of the probes 5c on the  
10 pads 23a. In addition, while the scrubbing direction is towards the center O of the membrane 5, there is a great likelihood that the scrubbing direction may be variable from probe (pad) to probe. Such variability from probe to probe in the amount of offset and in the amount of scrubbing makes it possible to design the positions of the  
15 probes 5c and the positions and shape of the pads 23a in preconsideration of the amounts and directions of scrubbing of the respective probes 5c, posing the problem that good reliability in connection may not be obtained.

## 20 SUMMARY OF THE INVENTION

An object of the present invention is to provide a probe card which has overcome the aforesaid problems with the prior art.

Another object of the present invention is to provide a probe card which is capable of diminishing position errors of probes in the  
25 X and Y directions immediately after the production of the membrane and positional displacement of probes due to aged deterioration as well as vibration and shock.

Yet another object of the present invention is to provide a probe card in which all of the probes provided on the membrane are substantially identical in the amount and direction of scrubbing and which is capable of adjusting the amount and direction of scrubbing according to the configuration of the terminals of a wafer IC.

5 In order to accomplish the aforesaid objects, the present invention provides a probe card adapted to be mounted to a wafer prober for transporting a semiconductor integrated circuit in an unpackaged state to a predetermined testing position and for use to supply a test signal from a semiconductor integrated circuit testing apparatus to the semiconductor integrated circuit and to transmit a response signal from the semiconductor integrated circuit to the semiconductor integrated circuit testing apparatus, the probe card comprising: a printed circuit board having a through-opening in its center; a mount having a base portion fitted in the through-opening of the printed circuit board; a stem mounted in generally the center of the mount and supported for vertically upward and downward movement; biasing means for applying a biasing force to the stem to urge the stem downwardly; a support member including a recess engaged with the lower end portion of the stem; retainer means for holding the support member in a position so as to extend downwardly from the bottom surface of the printed circuit board and for movement in an at least upward direction within a recess formed in the bottom surface of the base portion of the mount against the biasing force of the biasing means; a membrane formed of a flexible insulating thin film, the membrane having a plurality of probes extending downwardly from a central area of the bottom surface of

the membrane, the probes being adapted to contact with the terminals of the semiconductor integrated circuit in an unpackaged state, a portion of the upper surface of the membrane including at least the central area being fixed to the bottom surface of the support member through a resilient sheet-like member; and mounting means for securing the membrane to the bottom surface of the printed circuit board.

In a preferred embodiment, the stem is supported for movement in only vertically upward and downward directions by a bearing mounted in the mount, and the bearing is a linear ball bearing having a central opening through which the stem is passed.

The stem has a spherical abutment portion at its lower end, the abutment portion being rotatably engaged in the recess in the support member. The stem further has a retainer plate secured to the stem at the upper end of the spherical abutment portion. The compression coil spring surrounds the outer periphery of the stem and extends between the retainer plate and the upper wall of the recess formed in the bottom surface of the mount. The downward biasing force is applied to the stem by this compression coil spring.

The mount, in addition to the base portion fitted in the through-opening of the printed circuit board, has a flange formed around the upper portion of the base portion and engaged with the peripheral portion surrounding the through-opening of the printed circuit board, and a cylindrical protrusion formed on the upper portion of the base portion and having an outer diameter smaller than the outer diameter of the base portion.

The thickness of the base portion of the mount is sized such that

the lower end face of the base portion is substantially flush with the bottom surface of the printed circuit board when the base portion is fitted in the through-opening of the printed circuit board and the flange is engaged with the upper surface of the printed circuit board.

5       The cylindrical protrusion of the mount has formed in the upper surface a concentric circular recess in which a linear ball bearing supporting the stem for movement in only vertically upward and downward directions is mounted.

10       The cylindrical protrusion of the mount has formed also in the lower surface a concentric circular recess having a diameter larger than the diameter of the recess in the upper surface of the cylindrical protrusion and communicating with a concentric frusto-conical recess formed in the bottom surface of the base portion of the mount.

15       The diameter of the recess formed in the lower surface of the protrusion of the mount is smaller than the diameter of the upper bottom wall portion of the frusto-conical recess formed in the base portion, and the support member is movable upwardly until it comes into abutment with the upper bottom wall portion of the frusto-conical recess.

20       The support member has a circular flange around the upper portion thereof, and the flange is disposed in the frusto-conical recess formed in the bottom surface of the base portion of the mount. The outer peripheral face of the flange of the support member is tapered so as to conform with the peripheral wall of the frusto-conical recess.

25       The retainer means is in the form of a plate-like member having a through-opening in the center, and the support member is maintained with its flange in abutment with the upper surface of the

retainer means by the biasing force of the biasing means. The support member is loosely fitted in the through-opening of the retainer means while the flange is maintained in abutment with the upper surface of the retainer means by the biasing force of the biasing means.

The support member is in the form of a rectangular pillar-like member generally square in cross-section, and the lower portion of the support member extending below the flange is loosely fitted in a through-opening formed in the center of the retainer means.

The retainer means is in the form of a plate-like member having a through-opening in the center, and the through-opening is sized so as to be smaller than the outer diameter of the flange of the support member but larger than the outer dimension of the support member body.

The membrane is made generally cruciform, the central portion of the membrane, including the central area having the probes protruded downwardly from the bottom surface thereof, being generally rectangular and having rectangular tongues of approximately identical size and shape extending from four sides of the membrane central portion.

The membrane has its central portion, including the central area having the probes, bonded to the bottom surface of the support member while the rectangular tongues are attached at their end portions to the bottom surface of the printed circuit board in a slackened fashion.

The membrane is attached to the bottom surface of the printed circuit board by means of a connector in the form of a plate-like

member formed of a resilient insulating material, the connector being configured to establish electrical continuities across the thickness thereof at a plurality of locations in a mutually insulated manner. The tongues of the membrane may be adhesively bonded at their middle portions to the bottom surface of the retainer means.

The outer peripheral face of the circular flange of the support member is tapered so as to be closer to the central line of the support member as the face proceeds toward its upper end, and a plunger is mounted to the base portion of the mount, and is adapted to press on the tapered face approximately perpendicularly to the tapered face. The plunger is retractably mounted in a plunger receiving bore formed in the base portion of the mount. In a specific example, the plunger receiving bore has external threads formed around its outer peripheral surface, and the external threads are threadedly engaged with internal threads formed in the inner periphery of the plunger receiving bore to retractably mount the plunger in the plunger receiving bore. The plunger may be a ball plunger.

The mount may have a plurality of plunger receiving bores formed in the base portion at predetermined angular intervals, so that the plunger may be retractably mounted in any one of the plunger receiving bores.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a cross-sectional view illustrating one embodiment of the probe card according to the present invention;

Fig. 2A is a perspective view illustrating the membrane taken out of the probe card shown in Fig. 1;

Fig. 2B is a cross-sectional view illustrating an example of the probe card shown in Fig. 1 wherein the plunger is a ball plunger;

Fig. 3 is an enlarged cross-sectional view illustrating the connector and the surrounding portions of the probe card shown in

5 Fig. 1;

Figs. 4A - 4D are enlarged cross-sectional views of the membrane and the surrounding portions of the probe card shown in Fig. 1 illustrating the process of accommodating the variability in the height of the probes provided on the membrane of the probe card  
10 shown in Fig. 1 by overdriving of the stage of the wafer prober;

Figs. 5A and 5B are enlarged cross-sectional views of the plunger the surrounding portions of the probe card shown in Fig. 1;

Figs. 6A and 6B are vector diagrams illustrating the forces to which the mandrel block of the probe card shown in Fig. 1 is  
15 subjected as it is raised by overdriving of the stage of the wafer prober;

Fig. 7 is an exploded perspective view illustrating an example of the conventional probe card;

Figs. 8A and 8B are cross-sectional views of the probe card  
20 shown in Fig. 7 after it has been assembled illustrating how it is used;

Figs. 9A and 9B are bottom plan views of the membrane of the probe card shown in Fig. 7;

Fig. 10A is an enlarged plan view illustrating a portion of the connector of the probe card shown in Fig. 7;

25 Fig. 10B is a cross-sectional view of Fig. 10A taken along the line 10B - 10B;

Fig. 11A is a plan view illustrating an example of the membrane

of the probe card shown in Fig. 7;

Fig. 11B is a cross-sectional view of Fig. 11A taken along the line 11B - 11B;

Fig. 12A is a plan view illustrating another example of the membrane of the probe card shown in Fig. 7;

Fig. 12B is a cross-sectional view of Fig. 12A taken along the line 12B - 12B;

Fig. 13 is a schematic front view illustrating an example of the IC testing apparatus utilizing two wafer probers; and

Fig. 14 is a plan view of Fig. 13.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

One embodiment of the probe card according to the present invention will be described in details with reference to Figs. 1 - 6. In Figs. 1 - 6, those parts and elements corresponding to the parts and elements shown in Figs. 7 and 8 are designated by like reference numbers, and will not be further described unless necessary.

Like the prior art probe card, the probe card 3 according to the present invention includes a disc-like printed circuit board 4 and a membrane 5 formed of a resilient circular insulating thin film, the printed circuit board 4 having on its upper surface contacts 4b such as gold pads, for instance arranged with predetermined angular intervals in a circular array. These contacts 4b are to electrically contact the probe contact pins of the flog ring 2 (see Fig. 7), and accordingly are formed on the board at positions corresponding to the probe contact pins of the flog ring 2.

A number of contacts 4b formed on the upper surface of the

printed circuit board 4 are connected with corresponding ones of a multiplicity of terminals (electrodes), not shown, formed on the bottom surface of the printed circuit board 4 via the internal wiring of this printed circuit board 4 (conductor patterns, through-holes and the like formed in the layers of the multi-layered board).

The printed circuit board 4 is formed in its center with a through-opening 4a into which a mount 12 is fitted from above the board. In this embodiment, the mount 12 comprises a disc-like base portion 12c configured to fit in the through-opening 4a of the printed circuit board 4, a flange portion 12a formed around the upper peripheral portion of the base portion 12c and engaged with the peripheral portion surrounding the through-opening 4a of the printed circuit board 4, and a cylindrical protrusion 12d extending upwardly from the upper surface of the base portion 12c and having an outer diameter smaller than that of the base portion 12c. The thickness of the base portion 12c is sized such that the lower end face of the base portion 12c is substantially flush with the bottom surface of the printed circuit board 4 when the base portion is fitted in the through-opening 4a of the printed circuit board 4 and the flange portion 12a is engaged with the upper surface of the printed circuit board 4.

The cylindrical protrusion 12d of the mount 12 is formed in its upper surface with a concentric circular recess 12e in which a linear ball bearing 39 is mounted. The cylindrical protrusion 12d of the mount 12 is formed also in its lower surface with a concentric circular recess 12b. In this embodiment, the lower circular recess 12b is larger in diameter than the upper circular recess 12e. The protrusion

12d of the mount 12 is engaged in the through-opening 2a of the flog ring 2.

The protrusion 12d of the mount 12 is further formed in its center with a through-opening through which a loaded stem 8 is  
5 passed. The loaded stem 8 extends upwardly through the central opening of the linear ball bearing 39 up to a predetermined height beyond the top of the protrusion 12d, and is supported in a vertical orientation and for vertically upward and downward movement by the linear ball bearing 39 and the through-opening of the protrusion  
10 12d. It is to be noted that a disc-like bearing retainer 41 is affixed to the top surface of the protrusion 12d to secure the linear ball bearing 39 in the recess 12e. The bearing retainer 41 is of course formed in its center with a through-opening for passing the loaded stem 8 therethrough. Further, a snap ring 43 is engaged over the upper end  
15 portion of the protrusion 12d to prevent downward dislodgement.

The circular recess 12b in the bottom surface of the protrusion 12d of the mount 12 extends down through the base portion 12c to a position corresponding to the undersurface of the flange portion 12a to communicate with a concentric frusto-conical recess 12g formed  
20 in the base portion 12c of the mount 12. In this embodiment, the diameter of the circular recess 12b in the bottom surface of the protrusion 12d is smaller than the diameter of the upper bottom of the frusto-conical recess 12g so that a portion of the upper bottom of the recess 12g remains between the lower circular recess 12b of the  
25 protrusion and the frusto-conical recess 12g of the base portion 12c, that is, a shoulder or step is defined therebetween.

Housed in the lower circular recess 12b of the protrusion 12d of

the mount 12 are a compression coil spring 7 and a loaded stem 8 subjected to abutment portion 8a at its lower end larger than the diameter of the shank portion of the stem and a retainer plate 37 secured to the stem at the upper end of the hemispherical abutment portion 8a. The coil spring 7 surrounds the outer periphery of the lower shank portion of the loaded stem 8 and extends under compression between the retainer plate 37 and the upper bottom wall of the lower circular recess 12b of the protrusion 12d. It is thus to be understood that the urging force (biasing force) of the coil spring 7 is exerted through the retainer plate 37 on the loaded stem 8 to always bias the latter downwardly.

The abutment portion 8a at the lower end of the loaded stem 8 is rotatably accommodated in a circular recess 31c formed concentrically in the center of a rectangular pillar-like stiffener block 31 generally square in cross-section disposed below the mount 12, the recess 31c being cut from the top surface of the stiffener block 31 down thereinto. The stiffener block 31 includes an annular flange 31b extending radially outwardly from its upper portion. The flange 31b is disposed in the frusto-conical recess 12g formed in the base portion 12c of the mount 12. In this regard, the flange 31b has an outer diameter of the diameter of the frusto-conical recess 12g and is smaller in thickness than the depth of the frusto-conical recess 12g, and has an outer peripheral face tapered so as to conform with the inner peripheral face of the frusto-conical recess 12g.

In this embodiment, there is a circular retainer plate 33 having a generally square through-opening in the center thereof in which the stiffener block 31 is loosely fitted with its flange 31b engaged on the

upper surface of the retainer plate 33 which is in turn fastened to the bottom surface of the base portion 12c by screws 35 so that the flange 31b of the stiffener block 31 is disposed in the frusto-conical recess 12g of the base portion 12c. It will thus be appreciated that the stiffener block 31 is movable vertically upwardly against the biasing force of the coil spring 7 until the upper surface of the flange 31b comes into abutment with the upper bottom wall of the base portion 12c of the mount 12. It should be noted that the retainer plate 33 has an outer diameter approximately equal to that of the base portion 12c of the mount 12 and is attached concentrically to the mount 12. The through-opening of the retainer plate 33 is larger by a predetermined dimension than the outer diameter of the stiffener block 31 such that the stiffener block 31 is loosely fitted in the through-opening of the retainer plate 33. Specifically, there is a certain amount of clearance G between the outer periphery of the stiffener block 31 and the peripheral wall of the through-opening of the retainer plate 33 to permit movement of the stiffener block 31 by a certain distance in a horizontal direction as viewed in Fig. 1.

Disposed under the printed circuit board 4 is a connector 6 in the form of a circular plate-like member formed of a resilient insulating material, the connector 6 being configured to provide electrical conduction across the thickness thereof at a plurality of locations in a mutually insulated manner. The connector 6 is formed in the center thereof with a through-opening larger in diameter than the through-opening 4a of the printed circuit board 4 (larger than the outer diameter of the retainer plate 33).

While there are various constructions of the connector 6

providing electrical conduction across the thickness thereof, a connector 6 as described hereinbefore with reference to Figs. 10A and 10B may be used which comprises a circular sheet-like member 6c formed of a resilient insulating material such as insulating silicone rubber and a number of fine metal wires 6b extending through the thickness of the sheet-like member 6c in a mutually insulated manner. The length of the fine metal wires 6b is dimensioned such that they extend slightly beyond the upper and bottom surfaces of the sheet-like member 6c. Upon being subjected to only a slight pressure, this connector 6 permits good electrical connection to be established between components disposed on the opposite side surfaces of the connector.

The membrane 5 in this embodiment as well is a resilient insulating sheet formed of polyimide film, and as shown in Fig. 2A, is a generally cruciform member having rectangular tongues 5f extending perpendicularly from four sides of the membrane body which is generally square in this embodiment.

The membrane 5 has a grounding conductor (not shown) of copper foil, for example formed over the entire bottom surface thereof except a generally square area 5a concentric with the center O of the membrane body but smaller than the body. The bottom surface of the generally square area (which will be referred to as central area) 5a devoid of the grounding conductor has a plurality of probes (needle-like bumps made of conductor) 5c protruding downwardly therefrom. These probes 5c are arranged at positions corresponding to those of the terminals (leads) of a wafer IC since they are to be contacted with the terminals of the wafer IC when it has

been brought to the test position over the top surface of the wafer prober.

5 The upper surface of the membrane 5 is formed with a plurality of conductor patterns (electric wiring) 5b extending from each of the tongues 5f to the central area 5a. One end of each conductor pattern 5b terminating in the associated tongue 5f functions as a terminal 5d which is connected through the connector 6 with corresponding one of terminals formed in the bottom surface of the printed circuit board 4. The other end of each conductor pattern 5b terminating in the  
10 central area 5a is electrically connected via a through-hole for example with corresponding one of the probes 5c on the bottom surface of the membrane.

In this embodiment, the upper surface of the membrane 5 is adhesively attached to the bottom surface of the stiffener block 31 by  
15 means of a resilient sheet 44. Since the bottom surface of the stiffener block 31 has a generally square plane having approximately the same shape and surface area as the generally square region (including the central area 5a) of the membrane 5 excluding the tongues 5f and since the resilient sheet 44 is likewise of a complementarily square  
20 shape having about the same surface area, the membrane 5 has substantially only the tongues 5f free to move in a fluttery manner when it is bonded via the resilient sheet 44 to the bottom surface of the stiffener block 31.

The membrane 5 bonded via the resilient sheet 44 to the bottom  
25 surface of the stiffener block 31 is attached to the bottom surface of the printed circuit board 4 by holding the outer end portions of the four floatingly movable tongues 5f of the membrane between the

connector 6 and the retainer 11 and a tightening screw 15 from below to fasten this assembly to the bottom surface of the printed circuit board 4. It should be noted that the membrane 5 is attached to the bottom surface of the printed circuit board 4 such that there is some slack in the outer portions (the tongues 5f ) of the membrane 5 extending beyond the bottom surface of the stiffener block 31. Namely, the corresponding length of the tongues 5f of the membrane 5 extending from the outer edge of the bottom surface of the stiffener block 31 to the connector 6 is a certain amount longer than the slant distance between the outer edge of the bottom surface of the stiffener block 31 and the connector 6, so that once the membrane 5 has been attached to the bottom surface of the printed circuit board 4, the slack portions of the tongues 5f of the membrane 5 are deflected (curved) towards the bottom surface of the printed circuit board 4 in abutment against the bottom surface of the retainer plate 33, as shown in Fig. 1. The cruciform shape of the membrane 5 together with the stiffener block 31 being in engagement with the retainer plate 33 prevents the downward urging force of the coil spring 7 from being transmitted to the membrane 5 to thereby facilitate attaching the membrane 5 to the bottom surface of the printed circuit board 4 with some slack in the membrane 5. It is thus to be appreciated that the membrane 5 is not stretched by the urging force of the stiffener block 31 in contrast to the prior art, so that the position of the probe 5c provided in the central area 5a on the undersurface of the membrane may not be fluctuated.

While in this embodiment the middle portions of the tongues 5f of the membrane 5 in abutment against the bottom surface of the

retainer plate 33 are adhesively bonded to the bottom surface of the retainer plate 33 to prevent the slack portions of the tongues 5f from sagging downwardly, they need not necessarily be glued to the retainer plate.

5        In this embodiment, the screw 15 attaching the assembly of the retainer plate 33, the tongues 5f of the membrane 5, and the connector 6 to the bottom surface of the printed circuit board 4 are arranged to fasten the assembly to the bottom surface of the printed circuit board 4 by being threaded into threaded holes formed in the  
10       flange portion 12a of the mount 12. Since the stiffener block 31 is attached in position to the mount 12 by the retainer plate 33, attaching the aforesaid assembly to the bottom surface of the printed circuit board 4 by the screw 15 will complete assembly of the probe card 3. It is obvious to one skilled in the art that while only one  
15       screw 15 is illustrated in the drawings, a plurality of screws may be used as required.

      Since the membrane 5 is generally cruciform, the connector 6 may be in the form of a rectangular open frame member arranged to contact with those portions of the tongues 5f of the membrane 5  
20       containing the terminals 5d. Or alternatively, instead of the rectangular open frame member, the connector 6 may be a rectangular member having a circular opening. Likewise, the retainer plate 33 may be a rectangular open frame member like the connector 6 rather than the annular member, or alternatively may be  
25       a rectangular member having a circular opening.

      As is the case with the prior art example, the membrane 5 may be basically of the same construction as shown in Fig. 11 or 12,

although different in the shape. In case where the construction as shown in Fig. 12 is utilized, the upper surface of each of the tongues 5f the membrane 5 is formed with a predetermined number of pads (terminals) 5d which are connected through the connector 6 with  
5 corresponding terminals ~~4e~~ formed in the bottom surface of the printed circuit board 4, as shown in Fig. 3. Except for the radially outer end portions (where the pads 5d are formed) of the tongues 5f and the central area 5a, a grounding conductor is formed over the entire upper surface of the membrane 5 while the bottom surface of  
10 the membrane 5 is formed with a predetermined number of conductor patterns 5b extending radially from each of the tongues 5f to the central area 5a. Each of the pads 5d formed on each tongues 5f of the upper surface of the membrane 5 is connected via a through-hole with one end of corresponding one of the conductor patterns 5b  
15 on the bottom surface of the membrane 5 while the other end of the conductor pattern 5b may be electrically connected with the corresponding probe 5c provided in the central area 5a on the bottom surface of the membrane. It will be appreciated, however, that in this embodiment since the central area 5a of the membrane 5  
20 need not be transparent, the grounding conductor may be formed over the entire upper surface of the membrane 5 including the central area 5a except only the radially outer end portions of the tongues 5f.

As noted above, the outer peripheral face of the flange 31b of the  
25 stiffener block 31 is tapered at 31d so as to be closer to the central line (the axis of the stem) L of the probe card 3 as it proceeds toward its upper end. Mounted to the base portion 12c of the mount 12 is a



plunger 45 adapted to abut approximately perpendicularly against and press on the tapered face 31d. Specifically, the base portion 12c of the mount 12 has a vertically extending through-aperture 12f formed at a position of the base portion 12c adjacent to the frusto-  
5 conical recess 12g thereof as well as has a plunger receiving bore 12h (see Fig. 5A) extending perpendicularly from the tapered face of the frusto-conical recess 12g of the base portion 12c through the base portion 12c to the through-aperture 12f so as to communicate the plunger receiving bore 12h with the through-aperture 12f.

10 The through-aperture 12f formed through the base portion 12c of the mount 12 is used to insert the plunger 45 into the plunger receiving bore 12h and to adjust the length of the plunger 45 protruding into the frusto-conical recess 12g, as will be described hereinafter. Accordingly, it is required that the size of the through-  
15 aperture 12f be sized such as to permit the insertion and adjustment of the plunger 45.

As shown in Fig. 2B, in this embodiment the plunger 45 is a so-called ball plunger comprising a generally cylindrical case 45a having an open convergent forward end, a compression coil spring 45b  
20 housed in the case 45a, and a ball 45c as of steel subjected to the biasing force of the coil spring 45b towards the open end. Practically, after the coil spring 45b and the ball 45c are housed in the case 45a, the forward end of the case 45a is crimped inwardly.

The ball plunger 45 has its ball 45c normally partly extended  
25 from the open end of the case 45a under the biasing force of the compression coil spring 45b. Upon being pushed on from the exterior, caused to be retracted into the case 45a against the biasing

force of the coil spring 45b. That is, the ball 45c is adapted to be moved reciprocally in directions as indicated by the arrow in Fig. 2B.

The case 45a of the ball plunger 45 is formed around its outer periphery with external threads 4d which are threadedly engaged  
5 with the internal threads (not shown) formed in the inner periphery of the plunger receiving bore 12h in the base portion 12c of the mount 12 to adjustably mount the plunger 45 in the plunger receiving bore 12h. It will be appreciated that this arrangement permits the retractable (reciprocal) movement of the plunger 45 in  
10 the plunger receiving bore 12h, so that the position of the forward end, namely the ball 45c of the plunger 45 protruding from the forward end of the plunger receiving bore 12h may be adjusted by turning the plunger 45 by accessing the plunger through the plunger mounting and adjusting through-aperture 12f.

15 Adjusting the position of the plunger 45 permits adjustment of the pressing force of the plunger on the tapered face 31d of the flange 31b of the stiffener block 31 which in turn permits adjustment of the scrubbing amount of the probe 5c, as will be described below. The use of such plunger 45 provides the advantage of facilitating smooth  
20 upward movement of the stiffener block 31, since the ball 45c of the plunger 45 in contact with the tapered face 31d of the stiffener block 31 is forced into the plunger case 45a while being slidingly rotated as the stiffener block 31 is raised upwardly by overdriving of the stage 24 of the wafer prober 17, as will be described below with reference  
25 to Figs. 5A and 5B.

While in this embodiment the plunger 45 is located on the right-hand side of the mount base 12c as viewed in Fig. 1 so as to contact

the tapered face 31d of the flange 31b of the stiffener block 31 on the right-hand side thereof as viewed in Fig. 1, a plurality of plunger receiving bores may be formed through the mount base 12c at predetermined angular intervals such as 120°, 90°, or the like for example around the central axis (stem axis) L of the mount 12, so that any one of the plunger receiving bores which is oriented in a desired scrubbing direction of the probes 5c of the membrane 5 may be selected and a plunger 45 may be inserted into the selected plunger receiving bore.

10        When a plurality of plunger receiving bores are formed through the mount base 12c as noted above, the scrubbing direction of the probes 5c of the membrane 5 may be determined by the location of the plunger receiving bores. This arrangement provides the advantage of making it possible to select the scrubbing direction of the probes 5c of the membrane 5 so as to accommodate the configuration of the pads 23a of the wafer IC 23.

20        With the probe card 3 constructed as described according to the present invention, the loaded stem 8 is supported in a vertical orientation and for vertically upward and downward movement by the linear ball bearing 39 and the through-opening formed in the protrusion 12d, and hence is prevented from moving in the X and Y directions (horizontal) parallel to the plane of the wafer IC 23 placed on the stage 24 of the wafer prober 17. This in turn prevents the stiffener block 31 in engagement with the spherical abutment portion 8a of the loaded stem 8 from moving in the X and Y directions. Accordingly, the position in the X and Y directions of the probes 5c on the central area 5c of the membrane 5 bonded via the resilient

sheet 44 to the bottom surface of the stiffener block 31 may be determined with a high accuracy.

In addition, when the probe card 3 is fixed to the wafer prober 17 (the manner of fixing the probe card 3 is the same as with the prior art and is not described in details here), there is a difference ( $\Delta$ ) on the order of 100  $\mu\text{m}$  at maximum in the positions of the tips of the plurality of probes 5c as measured in the vertical axis (Z axis) (the elevations of the probe tips, that is, vertical distances of the probe tips from the surface (horizontal plane) of the wafer IC 23), as shown in Fig. 4A. This is due to dimensional tolerances (on the order of 5~10  $\mu\text{m}$  in manufacture of the probes themselves, variations in thickness of the membrane 5, resilient sheet 44, stiffener block 31 and others, and assembly errors.

With the construction of the probe card 3 according to the present invention, any differences  $\Delta$  in the elevations of the probe tips can be corrected by the following process:

(a) Raising the stage 24 of the wafer prober 17 with the wafer IC 23 under test fixedly placed thereon brings the pad 23a of the wafer IC 23 under test first into abutment with the one 5c1 of the probes 5c whose tip is at the lowest position, as shown in Fig. 4B. Further raising the stage 24 as indicated by the upwardly pointed arrow in Fig. 4B moves the membrane 5 and the resilient sheet 44 in unison with the stiffener block 31 upwardly against the biasing force of the coil spring 7 while the loaded stem 8 is also raised together with the stiffener block 31 as the coil spring 7 is progressively compressed.

(b) Continued raising of the stage 24 exerts an increasing pressure on that portion of the resilient sheet 44 overlying which portion is

partially compressed until the tip of the probe 5c1 becomes flush in height with the tips of most of the remaining probes, as shown in Fig. 4C. Consequently, the tips of most probes 5c comes into abutment with the respective opposing pads 23a of the wafer IC 23.

5 (c) Since the resilient sheet 44 has a limited elasticity, upon reaching the limit of elasticity, it is no further compressed. If there is still any probe 5c not in contact with the corresponding pad 23a of the wafer IC 23, as shown in Fig. 4D, the stiffener block 31 will be subjected to unequal pressures from the pad 23a contacted by the probes 5c  
10 whereby the stiffener block 31 is slightly turned about the spherical abutment portion 8a of the loaded stem 8 just like a rolling manner, with the result that the probe 5c which has not in contact with the pad 23a so far is moved down into contact with the opposing pad 23a.

As discussed above, after the tip of the lowest one probe 5c first  
15 abuts with the pad 23a of the wafer IC 23, further raising (which will be referred to as "overdriving" herein) the stage 24 by about 100  $\mu$ m accommodates the variations of the elevations of the probe tips to permit all of the probes 5c to contact the pads 23a of the wafer IC 23.

Overdriven by the stage 24, the stiffener block 31 is raised from  
20 the position shown in Fig. 5A to the position shown in Fig. 5B as indicated by the upwardly pointed arrow. During this overdriving process, the stiffener block 31 is subjected to a resultant force  $F_t$  as it undergoes a vertically upward force  $F_s$  from the stage 24 while at the same time undergoing a force  $F_p$  from the plunger 45 in the direction  
25 of its extension, as shown in Fig. 6A. The resultant force  $F_t$  can be resolved into a vertically upward force  $F_u$  and horizontal (orthogonal with the stem axis L) force  $F_h$ , as shown in Fig. 6B. The upward force

Fu is absorbed by the coil spring 7 while the horizontal force Fh acts to move the stiffener block 31 and the probes 5c of the membrane 5 bonded to the stiffener block 31 horizontally. It is thus to be understood that the horizontal force Fh represents the force with which the probes 5c scrub across the pads 23a of the wafer IC 23.

As will be appreciated from the foregoing disclosure, the use of probe card 3 according to the present invention ensures complete contact between the probes 5c of the membrane 5 and the pads 23a of the wafer IC 23 to be tested through the overdriving of the stage 24, and in addition facilitates the automatical scrubbing across the pads 23a of the wafer IC 23 by the probes 5c under the aforesaid horizontal force Fh to thereby maintain good electrical contact.

While the membrane 5 is made cruciform in shape in the embodiment described hereinabove, the configuration of the membrane 5 is not limited to the cruciform shape as it need only be so configured as to permit attachment of the membrane with some sag. It is also obvious to those skilled in the art that the configuration, dimensions, number, etc. of the probes 5c may be varied as required and that the configuration and construction of the mount 12, the loaded stem 8 and the stiffener block 31 and other components are not limited to those illustrated in the embodiment, either.

As will be apparent from the foregoing disclosure, according to the present invention, the loaded stem 8 is supported in a vertical orientation and yet for only vertical movement by the linear ball bearing and the through-opening formed in the mount, and is therefore prevented from moving in the X and Y directions

(horizontal directions). This in turn prevents the stiffener block in engagement with the loaded stem from moving in the X and Y directions, whereby the position in the X and Y directions of the probes 5c on the bottom surface of the membrane 5 bonded to the bottom surface of the stiffener block may be determined with a high accuracy, contributing to greatly enhancing the reliability in connection between the probes and the pads of the wafer IC.

In addition, even if there occurs aged deterioration in the flexibility of the membrane and elasticity of the coil spring, the maximal extent of the downward extension of the membrane below the printed circuit board is restricted to a constant value by virtue of the stiffener block being held by the retainer plate. On top of that, since the membrane is attached to the bottom surface of the printed circuit board in a slackened fashion so as not to be subjected to tension, the disadvantage with the prior art that a change in the extent of extension of the membrane causes a change in the elongation of the membrane, which in turn causes a variation in the positions of the probes along the X and Y directions is eliminated, and the probes are maintained at constant positions along the X and Y directions.

Moreover, since the loaded stem is held in a vertical orientation by the linear ball bearing and the through-opening in the mount, it is prevented from wobbling due to slight vibration and shock, accompanied with a change in the positions of the probes on the membrane, as is the case with the prior art.

Furthermore, any variation in the elevations of the probes may be taken up by the overdriving of the stage of the wafer prober to

thereby insure positive and reliable electrical connection between the probes and the pads of the wafer IC. In addition, the scrubbing amount of the probes on the pads of the wafer IC may be appropriately adjusted by adjusting the position of the plunger pressing on the stiffener block in the plunger receiving bore. What is more, since the driving force required for the probes to scrub the pads of the wafer IC is provided by the plunger pressing on the stiffener block as the latter is moved upwardly, it is advantageously possible to maintain the scrubbing amount and direction of all of the probes uniform.

Besides, when a plurality of plunger receiving bores are formed through the mount base at different angular positions therearound, the advantage is obtained that any one of the plunger receiving bores which is oriented in an appropriate position may be selected to set the direction of scrubbing so as to accommodate the configuration of the pads 23a of the wafer IC 23.



**WHAT IS CLAIMED IS:**

1. A probe card adapted to be mounted to a wafer prober for transporting a semiconductor integrated circuit in an unpackaged state to a predetermined testing position and for use to supply a test signal from a semiconductor integrated circuit testing apparatus to said semiconductor integrated circuit and to transmit a response signal from said semiconductor integrated circuit to said semiconductor integrated circuit testing apparatus, said probe card comprising:

a printed circuit board having a through-opening in its center;

a mount having a base portion fitted in the through-opening of said printed circuit board;

a stem mounted in generally the center of said mount and supported for vertically upward and downward movement;

biasing means for applying a biasing force to said stem to urge the stem downwardly;

a support member including a recess engaged with the lower end portion of said stem;

retainer means for holding said support member in a position so as to extend downwardly from the bottom surface of said printed circuit board and for movement in an at least upward direction within a recess formed in the bottom surface of said base portion of said mount against the biasing force of said biasing means;

a membrane formed of a flexible insulating thin film, said membrane having a plurality of probes extending downwardly from a central area of the bottom surface of the membrane, said probes being adapted to contact with the terminals of said semiconductor





integrated circuit in an unpackaged state, a portion of the upper surface of said membrane including at least said central area being fixed to the bottom surface of said support member through a resilient sheet-like member; and

mounting means for securing said membrane to the bottom surface of said printed circuit board.

2. The probe card of claim 1, wherein said stem is supported for movement in only vertically upward and downward directions by a bearing mounted in said mount.

3. The probe card of claim 2, wherein said bearing is a linear ball bearing having a central opening through which said stem is passed.

4. The probe card of claim 1 or claim 2, wherein said stem is provided with said downward biasing force by a compression coil spring mounted around the outer periphery of said stem.

5. The probe card of claim 1, wherein said mount has a frusto-conical recess formed in the bottom surface thereof, and said support member has a circular flange around the upper portion thereof, said flange being disposed in the frusto-conical recess formed in the bottom surface of the base portion of said mount.

6. The probe card of claim 1 or claim 5, wherein in addition to said base portion fitted in the through-opening of said printed circuit board, said mount has a flange formed around the upper portion of





the outer peripheral surface of said base portion and engaged with the peripheral portion surrounding the through-opening of said printed circuit board, and a cylindrical protrusion formed on the upper portion of said base portion and having an outer diameter smaller than the outer diameter of said base portion.

7. The probe card of claim 6, wherein the thickness of the base portion of said mount is sized such that the lower end face of said base portion is substantially flush with the bottom surface of said printed circuit board when said base portion is fitted in the through-opening of said printed circuit board and said flange is engaged with the upper surface of said printed circuit board.

8. The probe card of claim 6, wherein the cylindrical protrusion of said mount has formed in the upper surface a concentric circular recess in which a linear ball bearing supporting said stem for movement in only vertically upward and downward directions is mounted.

9. The probe card of claim 8, wherein the cylindrical protrusion of said mount has formed in the lower surface a concentric circular recess having a diameter larger than the diameter of said recess in the upper surface of said cylindrical protrusion and communicating with a concentric frusto-conical recess formed in the bottom surface of the base portion of said mount.

10. The probe card of claim 9, wherein the diameter of the

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recess formed in the lower surface of the protrusion of said mount is smaller than the diameter of the upper bottom wall portion of the frusto-conical recess formed in the bottom surface of the base portion, said support member being movable upwardly until it comes into abutment with the upper bottom wall portion of the frusto-conical recess.

11. The probe card of claim 5 or claim 10, wherein the outer peripheral face of the flange of said support member is tapered so as to conform with the inner peripheral wall of the frusto-conical recess.

12. The probe card of claim 9 or claim 10, wherein said stem has a spherical abutment portion at its lower end, said abutment portion being rotatably engaged in the recess in said support member, said stem having a retainer plate secured to the stem at the upper end of said spherical abutment portion, said compression coil spring surrounding the outer periphery of said stem and extending between the retainer plate and the upper wall of the recess formed in the bottom surface of the protrusion of said mount.

13. The probe card of claim 1, wherein said retainer means is in the form of a plate-like member having a through-opening in the center, and said support member has a circular flange around the upper portion thereof, said flange being maintained in abutment with the upper surface of said retainer means by the biasing force of said biasing means.





14. The probe card of claim 13, wherein said support member is loosely fitted in the through-opening of said retainer means while the flange of the support member is maintained in abutment with the upper surface of said retainer means by the biasing force of said biasing means.

15. The probe card of claim 1, wherein said support member is in the form of a rectangular pillar-like member generally square in cross-section and has a circular flange around the upper portion thereof, the lower portion of said support member extending below said flange being loosely fitted in a through-opening formed in the center of said retainer means.

16. The probe card of claim 15, wherein said retainer means is in the form of a plate-like member having a through-opening in the center, said through-opening being sized so as to be smaller than the outer diameter of the flange of said support member but larger than the outer dimension of the support member so that said support member is loosely fitted in the through-opening of said retainer means.

17. The probe card of claim 1, wherein the portion of the upper surface of said membrane including at least said central area is bonded to the bottom surface of said support member through a resilient sheet-like member.

18. The probe card of claim 1, wherein said membrane is made

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generally cruciform, the central portion of said membrane, including said central area having the probes protruded downwardly from the bottom surface thereof, being generally rectangular and having rectangular tongues of approximately identical size and shape extending from four sides of the membrane central portion.

~~19.~~ The probe card of claim 18, wherein said membrane has its central portion, including said central area having the probes protruded downwardly from the bottom surface thereof, bonded to the bottom surface of said support member while said rectangular tongues are attached at their end portions to the bottom surface of said printed circuit board in a slackened fashion.

~~20.~~ The probe card of claim 1, wherein said membrane is attached to the bottom surface of said printed circuit board by means of a connector in the form of a plate-like member formed of a resilient insulating material, said connector being configured to establish electrical continuities across the thickness thereof at a plurality of locations in a mutually insulated manner.

~~21.~~ The probe card of claim 18, wherein said tongues of said membrane are attached to the bottom surface of said printed circuit board by means of a connector in the form of a plate-like member formed of a resilient insulating material, said connector being configured to establish electrical continuities across the thickness thereof at a plurality of locations in a mutually insulated manner.

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~~22.~~ The probe card of claim 18, wherein said tongues of said membrane are adhesively bonded at their middle portions to the bottom surface of said retainer means.

23. The probe card of claim 1, wherein said support member has a circular flange around the upper portion thereof, and further including a plunger mounted to the base portion of said mount, said plunger being adapted to press on said flange.

24. The probe card of claim 23, wherein the outer peripheral face of said circular flange of said support member is tapered so as to be closer to the central line of the support member as the face proceeds toward its upper end, and the plunger mounted to the base portion of said mount is adapted to press on said tapered face approximately perpendicularly to the tapered face.

25. The probe card of claim 23 or 24, wherein said mount has a plunger receiving bore formed in the base portion, said plunger being retractably mounted in said plunger receiving bore.

26. The probe card of claim 25, wherein said plunger has external threads formed around its outer peripheral surface, said external threads being threadedly engaged with internal threads formed in the inner periphery of said plunger receiving bore to retractably mount the plunger in the plunger receiving bore.

27. The probe card of claim 23 or 24, wherein said plunger is a

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ball plunger.

28. The probe card of claim 23 or 24, wherein said mount has a plurality of plunger receiving bores formed in the base portion at predetermined angular intervals, said plunger being retractably mounted in any one of said plunger receiving bores.

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