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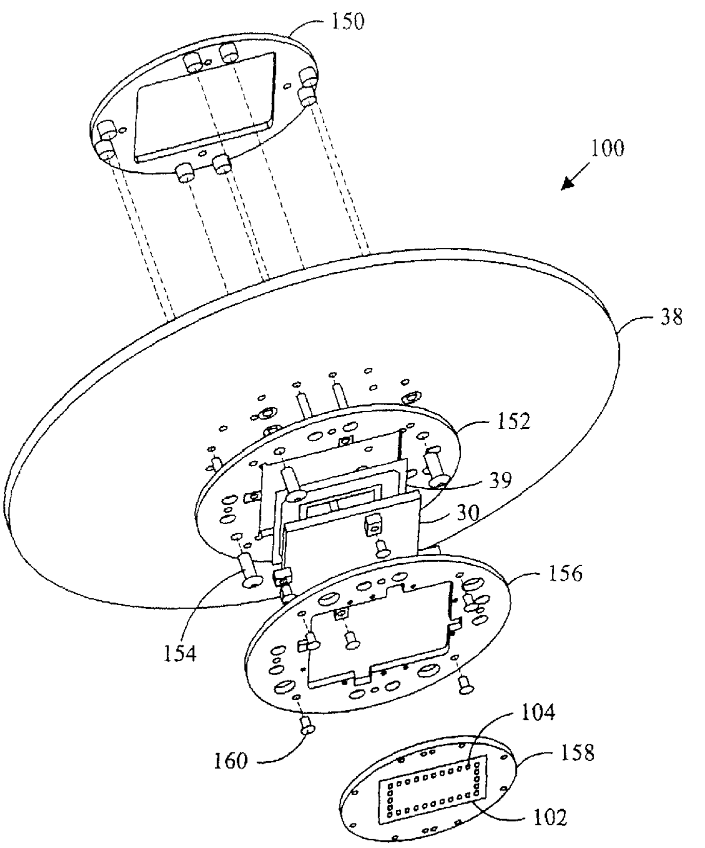
(54) Title: PROBE HEAD HAVING A MEMBRANE SUSPENDED PROBE



(57) Abstract: A probe head with membrane suspended probes.

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PROBE HEAD HAVING A MEMBRANE SUSPENDED PROBE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Patent Application No. 60/586,299 entitled "Probe Head Having a Membrane Suspended Probe," invented by Kenneth Smith, Michael Jolley and Victoria Van Sycle on July 7, 2004.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to probing assemblies of the type commonly used for testing integrated circuits (ICs) and, in particular, to a probing assembly providing finely pitched, compliant probes having very low inductance.

[0003] Integrated circuit technology permits fabrication of a number of discrete electronic circuit elements on a single substrate or "wafer." After fabrication, this wafer is divided into a number of rectangular-shaped chips or dies where each die includes a rectangular or other regular arrangement of metallized contact pads or bond pads through which input and output connections can be made to the electronic circuit on the die. Although each die is eventually packaged separately, for efficiency, testing of the circuit formed on each die is preferably performed while the dies are still joined together on the wafer. One typical procedure is to support the wafer on a flat stage or "chuck" and move the wafer in X, Y, and Z directions relative to the head of a probing assembly so that probe tips projecting from the probing assembly can be moved from die to die for consecutive engagement with the contact pads of each die. Respective signal, power, and ground conductors connect the probe tips to test instrumentation enabling each circuit to be sequentially connected to and operated by the test instrumentation.

[0004] One type of probing assembly used for testing integrated circuits utilizes a plurality of needle-like contacts arranged in a pattern matching the pattern of the contact pads on the device to be tested. FIGS. 1 and 2 show a probing assembly 20 that includes a needle card probe head 22 comprising an array of needle-like probes 24 restrained by upper 26 and lower 28 needle cards. The upper and lower needle cards 26, 28 contain patterns of holes that correspond to the contact pad arrangement of the IC or other device to be tested with the probing assembly 20. The lower end of each of the probes 24 extends through one of the holes in the lower needle card 28, terminating in a pointed probe tip. The upper end of each of the probes 24 is restrained by a hole in the upper needle card 26. The holes of the upper needle card 26 are covered by electrically conductive pads 32 arranged on a surface of a space transformer 30 (indicated by a bracket) preventing the upper ends of the probes from sliding through the upper needle card 26 when the lower ends of the probes are brought into pressing engagement with the contact pads on the device under test. The space transformer is a rigid, multilayer plate having electrically conductive contacts 32, 36 on the opposing surfaces that are electrically connected by conductive traces 34 that extend through the plate. The space transformer 30 re-routes the electrical signals from the finely pitched pattern of the needle probes 24 to a more coarsely pitched pattern obtainable on a probe card 38, a printed circuit board through which the test instrumentation is connected to the probing assembly.

[0005] The exemplary probing assembly 20 also includes an interposer 39 disposed between the space transformer 30 and the probe card 38. The interposer 39 typically includes a plurality of elastically deformable contacts electrically connected through a substrate to provide compliant electrical connections on opposing sides of the substrate. The compliance of the conductors compensates for variations in the distances separating the respective terminals of the space transformer 30 and the probe card 38 promoting reliable electrical connections there between.

[0006] The needle probes 24 typically comprise a wire including complementary bends that form an upper section and a lower section that lie generally parallel to, but offset from each other, adjacent, respectively, the upper and lower ends of the probe. The hole pattern of the lower needle card 28 is offset from the hole pattern in the upper needle card 26 to accommodate the offset of the ends of the probes. When the lower end of a probe is pressed into engagement with the contact pads on a die, the substantially columnar probe can bend at the offset, acting like a spring. The compliance provided by the elastic bending of the probe accommodates variations in probe length, probe head planarity, and wafer topography.

[0007] Needle card probing assemblies have been used extensively in wafer testing, but the trend in electronic production, and, in particular, IC production, to higher frequency, more complex circuits having smaller circuit elements and geometries has exposed several limitations of this type of probing device. First, the pitch, the distance between the probes, is limited by manufacturing tolerances and assembly considerations to about 125□m, a spacing greater than desirable for many ICs having finely pitched contact pads. In addition, the metallic contact pads of the dies oxidize rapidly and the tip of the probe must sharpened so that it can be pushed into the surface of the contact pad to achieve the good conductivity required for accurate measurements. This causes rapid dulling of the pointed probe ends, frequent bending or breaking of the probes, and may damage the contact pad if penetration is too great. The contact pad material also adheres to the probe and frequent cleaning is required which often damages the probes. Moreover, the inductance of parallel conductors is a function of the length and distance between the conductors. Typically, the relatively long, closely spaced, needle-like probes exhibit a single path inductance of 1-2 nH which is sufficient to substantially distort high frequency signals, limiting the usefulness of needle-type probes for testing high frequency devices.

[0008] A second type of probing assembly is described by Gleason et al. in United States Patent No. 6,708,386 B2, incorporated herein by reference. Referring to FIG. 3, a membrane probing assembly 40 includes a probe card 52 on which data and signal lines 48, 50 from the instrumentation are arranged and a membrane probing assembly 42. Referring to FIGS. 3-4, the membrane probing assembly 42 includes a support element 54 formed of incompressible material such as a hard polymer. This element is detachably connected to the upper side of the probe card by screws 56 and corresponding nuts 58 (each screw passes through a respective attachment arm 60 of the support element, and a separate backing element 62 evenly distributes the clamping pressure of the screws over the entire back side of the supporting element). Different probing assemblies having different contact arrangements can be quickly substituted for each other as needed for probing devices having different arrangements of contact pads.

[0009] Referring to FIGS. 4-5, the support element 54 includes a rearward base portion 64 to which the attachment arms 60 are integrally joined. Also included on the support element 54 is a forward support or plunger 66 that projects outwardly from the flat base portion. This forward support has angled sides 68 that converge toward a flat support surface 70 so as to give the forward support the shape of a truncated pyramid. Referring also to FIG. 4, a flexible membrane assembly 72 is attached to the support after being aligned by means of alignment pins 74 included on the base portion. This flexible membrane assembly is formed by one or more plies of insulative polyimide film, and flexible conductive layers or strips are provided between or on these plies to form the data/signal lines 76.

[0010] When the support element 54 is mounted on the upper side of the probe card 52 as shown in FIG. 5, the forward support 66 protrudes through a central opening 78 in the probe card so as to present the contacts which are arranged on a central region 80 of the flexible membrane assembly in suitable position for pressing engagement with the contact pads of the die or other device under test. Referring to FIG. 4, the membrane assembly includes radially extending arm segments 82 that are separated by inwardly curving edges 84 that give the assembly the shape of a formee cross, and these segments extend in an inclined manner along the angled sides 68 thereby clearing any upright components surrounding the pads. A series of contact pads 86 terminate the data/signal lines 76 so that when the support element is mounted, these pads electrically engage corresponding termination pads provided on the upper side of the probe card so that the data/signal lines 48 on the probe card are electrically connected to the contacts on the central region.

[0011] The probing assembly 42 is capable of probing a dense arrangement of contact pads over a large number of contact cycles in a manner that provides generally reliable electrical connection between the contacts and pads in each cycle despite oxide buildup on the contact pads. The membrane assembly is so constructed and connected to the support element that the contacts on the membrane assembly wipe or scrub, in a locally controlled manner, laterally across the contact pads when brought into pressing engagement with these pads.

[0012] FIG. 8 is an enlarged view of the central region 80a of the membrane assembly 72a illustrating an embodiment in which the contacts 88 are arranged in a square-like pattern suitable for engagement with a corresponding square-like arrangement of contact pads on a die. The membrane assembly provides space transformation from the very fine pitch of the densely packed contacts 88 to the more coarsely pitched contact pads 86 terminating the data/signal lines 76.

[0013] Referring also to FIG. 9a, which represents a sectional view taken along lines 9a--9a in FIG. 8, each contact comprises a relatively thick rigid beam 90 at one end of which is formed a rigid contact bump 92. The contact bump includes thereon a contacting portion 93 which comprises a nub of rhodium fused to the contact bump. Using electroplating, each beam is formed in an overlapping connection with the end of a flexible conductive trace 76a to form a joint therewith. This conductive trace in conjunction with a back-plane conductive layer 94 effectively provides a controlled impedance data or signal line to the contact because its dimensions are established using a photolithographic process.

[0014] The membrane assembly is interconnected to the flat support surface 70 by an interposed elastomeric layer 98, which layer is coextensive with the support surface and can be formed by a silicone rubber compound. The flat support surface, as previously mentioned, is made of incompressible material and is preferably a hard dielectric such as polysulfone or glass. When one of the contacts 88 is brought into pressing engagement with a respective contact pad 100 of a die, as indicated in FIG. 10, the resulting off-center force on the rigid beam 90 and bump 92 structure causes the beam to pivot or tilt against the elastic recovery force provided by the elastomeric pad 98. This tilting motion is localized in the sense that a forward portion 102 of the beam moves a greater distance toward the flat support surface 70 than a rearward portion 104 of the same beam. The effect is such as to drive the contact into lateral scrubbing movement across the contact pad with a dashed-line and solid-line representation showing the beginning and ending positions, respectively, of the contact on the pad. In this fashion, the insulating oxide buildup on each contact pad is abraded so as to ensure adequate contact-to-pad electrical connections.

[0015] A locally scrubbing, membrane probing assembly provides contacts which can be finely pitched to engage contact pads on physically smaller devices and combines high conductivity with ruggedness and resistance to wear and damage. Membrane suspended probes can also combine a greater section and shorter length to exhibit much lower inductance than typical needle probes permitting their use at higher frequencies and producing less signal distortion at all frequencies. However, the probes and the signal and data lines are created on the surface of the membrane and connect to probe card terminals arranged around the periphery of the membrane. Heretofore, membrane suspended probes have not been adaptable for use with the probe cards and space transformers suitable for use with a needle card-type probe heads where the signal paths pass through the center of the probing assembly and are arranged substantially parallel to the central axis of the probing assembly. What is desired, therefore, is a device and method for adapting robust, finely pitched, low inductance membrane suspended probes for use with the components of a probing assembly suited for use with a needle-type probe head.

Brief Description of the Several Views of the Drawings

[0016] FIG. 1 is an exploded perspective schematic diagram of a needle-type probing assembly.

[0017] FIG. 2 is a cross-section of a needle card probe head for use in a needle-type probing assembly.

[0018] FIG. 3 is a perspective view of a membrane probing assembly bolted to a probe head and a wafer supported on a chuck in suitable position for probing by this assembly.

[0019] FIG. 4 is a bottom view showing various parts of the probing assembly of FIG. 3, including a support element and flexible membrane assembly, and a fragmentary view of a probe card having data/signal lines connected with corresponding lines on the membrane assembly.

[0020] FIG. 5 is a side elevational view of the membrane probing assembly of FIG. 3 where a portion of the membrane assembly has been cut away to expose hidden portions of the support element.

[0021] FIG. 6 is a top elevational view of an exemplary support element.

[0022] FIGS. 7a and 7b are schematic side elevational views illustrating how the support element and membrane assembly are capable of tilting to match the orientation of the device under test.

[0023] FIG. 8 is an enlarged top elevational view of the central region of the construction of the membrane assembly of FIG. 4.

[0024] FIGS. 9a-9b are sectional views taken along lines 9a--9a in FIG. 8 first showing a contact before touchdown and then showing the same contact after touchdown and scrub movement across its respective pad.

[0025] FIG. 10 is a schematic side view showing, in dashed-line representation, the contact of FIGS. 9a-9a at the moment of initial touchdown and, in solid-line representation, the same contact after further vertical overtravel by the pad.

[0026] FIG. 11 is an exploded perspective schematic diagram of a probing assembly including a space transformer suitable for a needle-type probe head and a probe head having membrane suspended probes.

[0027] FIG. 12 is a schematic cross-sectional view of the probing assembly of FIG. 11.

[0028] FIG. 13 is a schematic cross-sectional view of a membrane suspended probe tip contacting a contact pad of a device under test.

[0029] FIG. 14 is a schematic cross-sectional view of a probe head adaptable to a needle card-type space transformer and incorporating a second embodiment of a membrane suspended probe.

[0030] FIG. 15 is bottom view of a space transformer including a plurality of probe tiles with membrane suspended probes.

[0031] FIG. 16 is a cross-sectional view of a probe head tile including a membrane suspended probe.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0032] Referring in detail to the drawings where similar parts of the invention are identified by like reference numerals, and, more particularly, to FIG. 1, an embodiment of a probing assembly 20 suitable for use with needle-type probes includes as its major functional components a probe card 38, an interposer 39, a space transformer 30, and a probe head 22. Referring also to FIG. 2, needle-like probes 24 in the probe head provide a means of making temporary interconnections to contact pads on a die included on a semiconductor wafer or other device under test (DUT) and conducting signals to and from the integrated electrical circuit on the DUT. The needle-like probes conduct the signals to and from the die through the probe head 22 to conductive terminals 32 or pads on the space transformer 30. The signal paths of the needle card-type probing assembly are typically grouped around the center of the probing assembly and substantially normal to the device under test. While needle probes have been used extensively in probing ICs, needle probes have a number of limitations making them less than ideal for probing ICs and other devices having finely pitched features or operating at high frequencies.

[0033] On the other hand, membrane probes can exhibit substantially lower inductance than needle-type probes making membrane probes desirable for probing high frequency circuitry. In addition, a membrane suspended probe tip can be arranged to provide local contact scrubbing to penetrate the insulating oxide layer that forms on the IC contact pad without accumulating contact pad material on the probe tip as is common with needle-type probes. Heretofore, probes suspended on a membrane have not been adaptable to probing assemblies intended for use with needle-type probes because the membrane suspended probes and the conductive traces connecting the probes to the probe card are disposed on the surface of an elastic membrane with the traces radiating outward over the surface of the membrane to connect to probe card terminals arranged around the periphery of the membrane. The current inventors concluded that the performance advantages of membrane suspended probes could be provided for a probing assembly originally intended for use with needle-type probes, if the membrane suspended probes could be conductively connected to a space transformer located on the opposite side of the membrane from the probe tips. FIGS. 11 and 12 illustrate a probing assembly 100 including components suitable for use with a needle card type probe head that includes a probe head 102 having a plurality of elastic membrane suspended probes 104. The needle card-type probing assembly can be converted to a probing assembly with membrane suspended probes by removing the needle card-type probe head and replacing it with the membrane probe head 102 that interfaces with the space transformer suitable for interfacing with the needle card-type probe head. In the schematic cross-sectional view of FIG. 12, certain elements and components are shown exaggerated, for illustrative clarity.

[0034] The probe card 38 is generally a conventional circuit board substrate having a plurality of terminals 120 (two of many shown) disposed on a surface thereof. The terminals provide an interface for wires 122 that connect instrumentation (not shown) to the probing assembly. As illustrated, the wires 122 may be connected to terminals 120 on one side of the probe card 38 which are, in turn, connected by conductive vias 124 to terminals 126 or traces on the opposing side of the circuit board. Additional components (not shown), such as active and passive electronic components, connectors, and the like, may be mounted to the probe card 38 and connected to additional terminals 120. The probe card 38 is typically round and commonly has a diameter on the order of 12 inches. The terminals 122, 126 on the circuit board are often arranged at a 100 mil pitch or separation distance.

[0035] While some probing assemblies do not utilize an interposer, the probing assembly 100 includes an interposer 39 disposed between the probe card 38 and the space transformer 30. An interposer comprises interconnected electrical contacts disposed on opposing sides of a substrate so that components on opposing sides of the substrate can be conductively interconnected. An interposer is often used in a probing assembly to facilitate reliable conductive connection between the terminals of a probe card and the terminals on a space transformer. The interposer is also aids in accommodating differences in thermal expansion of the probe card 38 and the space transformer 30. The interposer 39 comprises a substrate 128 and a plurality of fuzz buttons 130 (two are shown) that protrude through holes in the substrate. The fuzz buttons 130 each comprise a fine wire that is compressed into a small cylindrical shape to produce an electrically conductive, elastic wire mass. As a general proposition, the fuzz buttons 130 are arranged at a pitch which matches that of the terminals 126 of the probe card 38. One end of each of the conductive fuzz buttons 130 is in contact with a terminal on the probe card 38 while the second end of the fuzz button is in contact with a terminal 140 on the space transformer 30. The elastic fuzz buttons 130 are compressed providing compliance to accommodate variations in the separation distances between of the various terminals of the probe card and the space transformer and exerting pressure on the contacts to promote good conductivity.

[0036] The fuzz buttons 130 protruding through the substrate 128 of the interposer 39 contact conductive terminals 140 on one side of the space transformer 30. The space transformer 30 (indicated by a bracket) comprises a suitable circuitized substrate 142, such as a multi-layer ceramic substrate having a plurality of terminals (contact areas, pads) 140 (two of many shown) disposed on the surface adjacent to the interposer 39 and a plurality of terminals (contact areas, pads) 144 (two of many shown) disposed on the opposing surface. In the exemplary probing assembly 100, the contact pads 140 adjacent the interposer 39 are disposed at the pitch of the terminals of the probe card 38, and the contact pads 144 arranged on the opposing surface of the space transformer 30 are disposed at a finer pitch corresponding to the pitch and arrangement of the needle-type probes included in the needle card probe head to which the space transformer was intended to interface. While the pitch of the terminals of the probe card 38 is approximately 100 mil, the pitch of needle-type probes can be as fine as approximately 125 □m. Conductive traces 146 in the multilayer substrate 142 of the space transformer 30 re-route the electrical connections from the finely pitched pattern required to interface with the probe head to the more coarsely pitched pattern that is obtainable with a printed circuit board, such as the probe card 38.

[0037] The various elements of the probing assembly 100 are stacked and any suitable mechanism for stacking these components and ensuring reliable electrical contacts may be employed. As illustrated, the probing assembly 100 includes a rigid rear mounting plate 150 arranged on one side of the probe card 38 and a rigid front mounting plate 152 disposed on the opposing side of the probe card. Screws 154 restrain the front mounting plate to the rear mounting plate 150. A rectangular stand-off 156 with a central aperture to receive the space transformer 30 is attached to the front mounting plate. A mounting ring 158 which is preferably made of a springy material such as phosphor bronze and which may have a pattern of springy tabs extending therefrom, is attachable by screws 160 to the stand-off 156 with the space transformer 30 captured between the mounting ring and the stand-off.

[0038] The mounting ring 156 also captures and retains a probe head 102 comprising a multilayer substrate 160 (indicated by a bracket) and a plurality of electrically conductive, membrane suspended probes 104. The probes 104 comprise, generally, a relatively thick, rigid beam 164 with a beam contact 166 proximate one end of the beam and a probe tip 168 projecting from the beam proximate the second end of the beam. Although other shapes and materials may be utilized, typically, the probe tip 168 has the shape of a truncated pyramid and the projecting end of the probe tip may be coated with a layer of nickel or rhodium to provide good electrical conductivity and wear resistant when repeatedly being pressed into engagement with contact pads on a device under test. The beam contact 166 has a mushroom-shaped cross-section comprising a contact button with rounded edges, facilitating movable contact with the terminals 144 of the space transformer 30, and a cylindrical or prismatic base section that is slightly smaller than the contact button and connects the contact button to the beam. The beam contact 166 projects from the side of the beam 164 opposite the beam tip 168 and in the opposite direction. As illustrated in FIG. 12, the beam contact projects at least flush with the upper surface of the multi-layer substrate 160 so that it is exposed from the upper surface of the substrate enabling conductive contact with the corresponding terminal 144 of the space transformer 30. The ratio of the cross-section to the length is much greater for the membrane suspended probe 104 than for the typical needle probe 24 and, unlike the needle probe, the locally scrubbing, membrane suspended probe does not require a sharply pointed tip to penetrate the oxide buildup on the contact pads of the DUT. The membrane probe head 102 has a single path inductance significantly less than 0.5 nH and been demonstrated with a single path inductance of 0.2 nH. As a result, the membrane suspended probes produce significantly less signal distortion and can be used at higher frequencies than needle-type probes that typically have inductance greater than 1 nH and often as much as 2 nH.

[0039] Gleason et al., U.S. Patent No. 6,708,386 B2, incorporated herein by reference, disclose a "bottom up" and a "top down" method for producing membrane probes. Either method can used to produce the membrane probe head 102. Membrane suspended probes 104 produced by these methods can be constructed in arrays with pitches less than 100 □m permitting the membrane suspended probes to used for testing devices with more dense contact pads than needle probes which are typically limited to pitches greater than 125 □m by manufacturing and assembly considerations. Portions of the beam contact 104 that engage the terminal 144 may also be coated with a layer nickel or rhodium to enhance electrical conductivity and wear resistance.

[0040] The multilayer substrate 160 comprises an elastic membrane 170 and a plurality of flexible insulating layers 172, 174. The elastic membrane 170 is arranged proximate to or in contact with the surface of the space transformer 30. The elastic membrane 170 may comprise a silicone rubber compound, such as ELMER'S STICK-ALLJ made by the Borden Company or Sylgard 182 by Dow Corning Corporation and is capable of exerting an elastic restoring force to a surface when the surface of the membrane is deformed. The multilayer substrate 160 of the probe head also comprises flexible first 172 and second 174 insulating layers or members. The first insulating layer 172 is disposed between the bottom surface 176 of the elastic membrane 170 and the upper surface of the beam 164 of the probe 104. The second insulating layer 174 extends downward from the bottom surface of the first insulating layer 172 to a depth approximating the thickness of the beam portion 164 of the probe 104. The first 172 and second 174 insulating layers are relatively thin and flexible in a direction normal to their surfaces but are sufficiently rigid in directions parallel to their surfaces to secure the lateral positions of the probes 104. The first 172 and second 174 insulating layers may comprise polyimide, but can comprise any other dielectric material having appropriate physical properties.

[0041] Referring to FIG. 13, as the probe tip 168 is brought into pressing engagement with a respective contact pad 200 on a device under test 202, the resulting contact force urges the probe tip upward toward position 168'. Upward displacement of the probe 104 is resisted by the contact force at the interface of the space transformer contact 144 and the beam contact 166. As a result, the probe 104 is rotated toward position 104' causing the end of the probe tip 168 to be displaced laterally on the contact pad 200. This lateral displacement or scrubbing ("s") abrades the insulating oxide buildup on the contact pad ensuring reliable conductance between the probe tip 168 and the contact pad. As the probe tip 168 is displaced upward, the flexible first insulating layer 172 is displaced upward by the movement of the beam 166 pushing upward on the elastic membrane 170. The surface of the membrane is stretched and distorted and the elastic membrane exerts a force to restore the first insulating layer 172 and the probe 104 to the "at rest" position. When the upper surface of the elastic membrane 170 contacts the surface of the space transformer 30, upward displacement of the probe 104 and distortion the lower surface of the elastic membrane compresses the membrane producing additional restorative force on the first insulating layer 172. The restorative force exerted by the elastic membrane 170 on the flexible insulating layer 172 returns the probe tip 104 to the initial position when the DUT 202 is moved away from the probe head 102 relieving the contact force at the probe tip 168.

[0042] Referring to FIG. 14, a probe head 250 incorporating a second embodiment of a membrane suspended probe 215 may be used with space transformers 30 having projecting contacts 258, such as solder balls. The probe 251 comprises a beam 252 having a probe tip 254 projecting from the beam at one end. The beam contact 256 is exposed from the upper surface of the elastic membrane 260 through an aperture 266 that extends through the elastic membrane and the first insulating layer 262. The projecting space transformer contact 258 contacts the beam 252 at the exposed beam contact 256 proximate the end of the beam opposite the probe tip 254. When a contact pad 200 of a DUT 202 is pushed into contact with the probe tip 254 the probe rotates around the beam contact 256 producing the scrubbing action that removes the oxide buildup from the contact pad.

[0043] Referring to FIGS. 15 and 16, in another embodiment of the probe head having membrane suspended probes 300, one or more membrane suspended probes 104 are included on a tile 302 that can be adhered to a surface of a space transformer 30. The tiles 302 comprise one or more probes 104 having a beam portion 164, an elastic membrane 304, a first insulating member 306 interposed between the beam portion of the probe and the lower surface of the elastic membrane, and a second insulating member 308 extending downward from the first insulating member approximately the depth of the beam portion of the probe. The tile 302 is secured to the surface of the space transformer 30 by a double sided adhesive interface 310 that frames the upper surface of the tile's elastic membrane 304. A space transformer 30 originally intended to interface with a needle card-type probe head can be converted to membrane suspended probes by removing the needle card-type probe head and adhering one or more tiles 302 including one or more membrane suspended probe 104 to the surface of the space transformer so that the probe's contact button 166 is positioned for contact with the space transformer contact 144. When the probe tip 168 is pressed into contact with a contact pad on a DUT, probe 104 rotates about the interface of the contact button 166 and the space transformer contact 144. The end of the beam portion 164 adjacent the probe tip 168 rotates upward producing local scrubbing of the probe tip and causing the first insulating layer 306 to distort the surface of the elastic membrane 304 which resists distortion with a restoring force. One or more blank filler tiles 312 can be adhesively adhered to the surface of the space transformer 30 to provide the probe head with a continuous surface.

[0044] A probe head with membrane suspended probes permits a needle card-type probing assembly to be converted to utilize membrane suspended probes which can be more closely pitched and exhibit substantially lower inductance than needle-type probes. Signal distortion is substantially reduced permitting testing of devices operating at higher frequencies and greater measurement accuracy at all frequencies.

[0045] The detailed description, above, sets forth numerous specific details to provide a thorough understanding of the present invention. However, those skilled in the art will appreciate that the present invention may be practiced without these specific details. In other instances, well known methods, procedures, components, and circuitry have not been described in detail to avoid obscuring the present invention.

[0046] All the references cited herein are incorporated by reference.

[0047] The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

CLAIM(S)

I claim:

1. A probe head comprising:

(a) an elastic membrane having a first surface and an opposing second surface, said elastic membrane capable of exerting a restoring force when one of said first and said second surfaces is distorted; and

(b) a conductive probe comprising a beam having a first end and a second end, a probe tip for contacting a device under test proximate said first end of said beam, and a beam contact proximate said second end of said beam and exposed from said first surface of said elastic membrane, said beam movable to deform said second surface of said elastic membrane.

2. The probe head of claim 1 further comprising an insulating member interposed between said beam and said elastic membrane, said insulating member movable by said beam to deform said second surface of said elastic membrane.

3. The probe head of claim 1 wherein said beam contact projects from said beam at least flush with said first surface of said elastic membrane.

4. A probe head comprising:

(a) an elastic membrane having a first surface and an opposing second surface, said elastic membrane capable of exerting a restoring force when at least one of said first and said second surfaces is distorted;

(b) a conductive probe comprising a beam having a first end, a second end, and a depth; a probe tip proximate said first end of said beam and projecting from said beam in a first direction; and a beam contact proximate said second end of said beam exposed to contact from said first surface of said elastic membrane; and

(c) a first insulating member having a first surface engaging said beam and a second surface engaging said second surface of said elastic member, said first insulating member movable by said beam to deform said second surface of said elastic membrane.

5. The probe head of claim 4 wherein said beam contact projects from said beam in a direction opposite said first direction and at least flush with said first surface of said elastic membrane.

6. The probe head of claim 4 further comprising a second insulating member having a first surface proximate said first surface of said first insulating member and a thickness approximating said depth of said beam.

7. A probing assembly comprising:

(a) a space transformer including an exposed conductive space transformer contact;

(b) an elastic membrane having a first surface restrainable by said space transformer and an opposing second surface, said elastic membrane capable of exerting a restoring force when said second surface is distorted; and

(c) a conductive probe comprising a beam having a first end and a second end, a probe tip for contacting a device under test proximate said first end of said beam, and a beam contact proximate said second end of said beam and arranged to contact said space transformer contact, said beam movable to deform said second surface of said elastic membrane.

8. The probing assembly of claim 7 further comprising a first insulating member interposed between said beam and said elastic membrane, said first insulating member movable by said beam to deform said second surface of said elastic membrane.

9. The probe head of claim 7 wherein said beam contact projects from said beam at least flush with said first surface of said elastic membrane.

10. A probing assembly comprising:

(a) a space transformer having a surface and including a conductive space transformer contact exposed at said surface;

(b) an elastic membrane having a first surface restrainable by said surface of said space transformer and an opposing second surface, said elastic membrane capable of exerting a restoring force when said second surface is distorted;

(c) a conductive probe comprising a beam having a first end, a second end, and a depth, a probe tip proximate said first end of said beam and projecting from said beam in a first direction, and a beam contact proximate said second end of said beam and arranged to contact said space transformer contact; and

(d) a first insulating member having a first surface engaging said beam and a second surface engaging said second surface of said elastic member, said insulating member movable by said beam to deform said second surface of said elastic membrane.

11. The probe head of claim 10 wherein said beam contact projects from said beam in a direction opposite said first direction and at least flush with said first surface of said elastic membrane.

12. The probe head of claim 10 further comprising a second insulating member having a first surface proximate said first surface of said first insulating member and a thickness approximating said depth of said beam.

13. A method of reducing an inductance of a needle card probe assembly including a needle card probe head and a space transformer having a space transformer contact arranged to interface with said needle card probe head, said method comprising the steps of:

(a) disengaging said needle card probe head from said space transformer; and

(b) engaging said space transformer with a membrane probe head comprising;

(i) an elastic membrane having a first surface restrainable by said space transformer and an opposing second surface, said elastic membrane capable of exerting a restoring force when second surface is distorted;

(ii) a conductive probe comprising a beam having a first end, a second end, and a depth, a probe tip proximate said first end of said beam and projecting from said beam in a first direction, and a beam contact proximate said second end of said beam and arranged to contact said space transformer contact; and

(iii) a first insulating member having a first surface engaging said beam and a second surface engaging said second surface of said elastic member, said insulating member movable by said beam to deform said second surface of said elastic membrane.

14. The method of claim 13 wherein said beam contact of said membrane probe head projects from said beam in a direction opposite said first direction and at least flush with said first surface of said elastic membrane.

15. The method of claim 13 wherein said membrane probe head further comprising a second insulating member having a first surface proximate said first surface of said first insulating member and a thickness approximating said depth of said beam.

16. The method of claim 13 wherein said conductive probe has a single path inductance less than one nano-Henry.

17. The method of claim 13 wherein said conductive probe has a single path inductance less than one-half nano-Henry.

18. The method of claim 13 wherein said conductive probe has a single path inductance less than one-fourth nano-Henry.

19. The method of claim 13 wherein the step of engaging said space transformer with said membrane probe head comprises the step adhering a tile including said elastic membrane and said conductive probe to a surface of said space transformer.

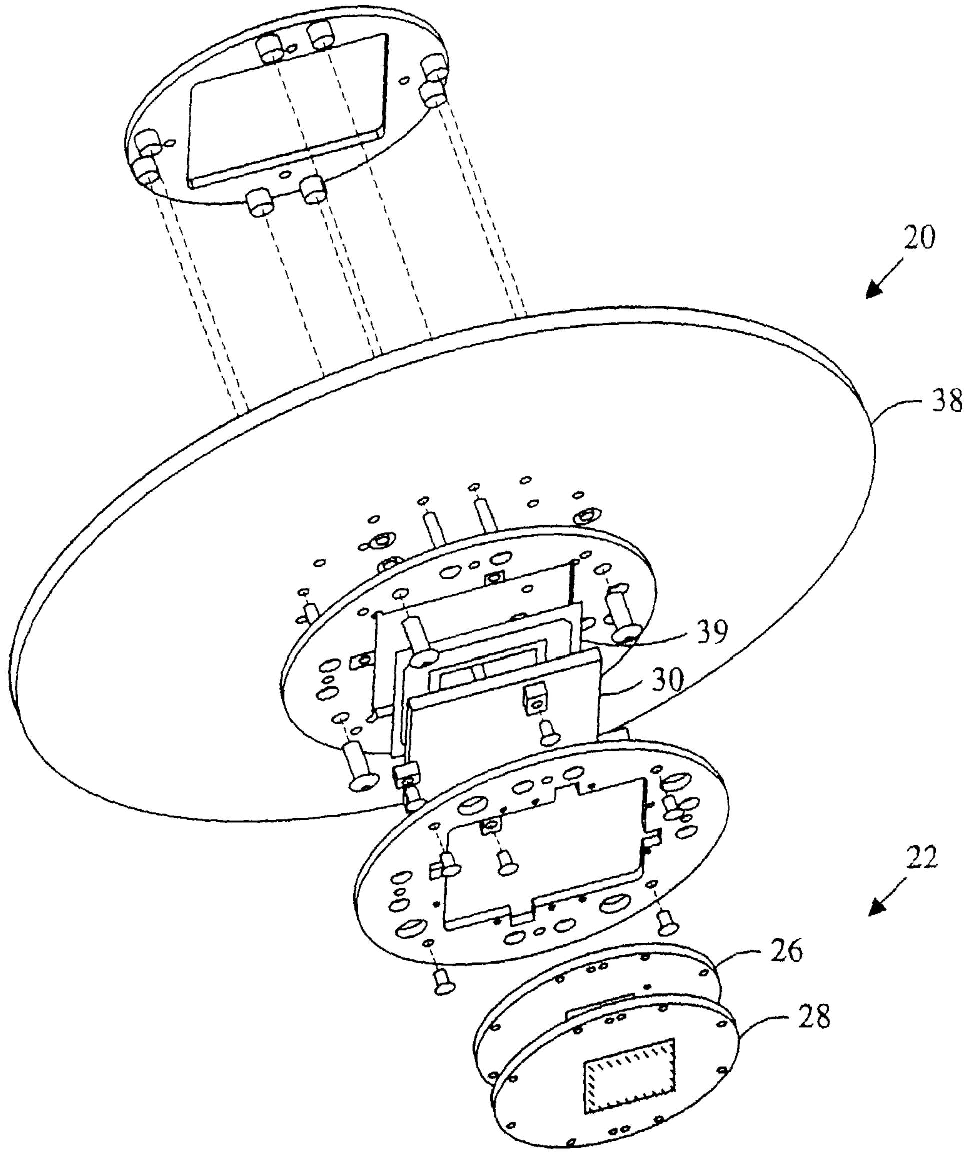


FIG. 1
(PRIOR ART)

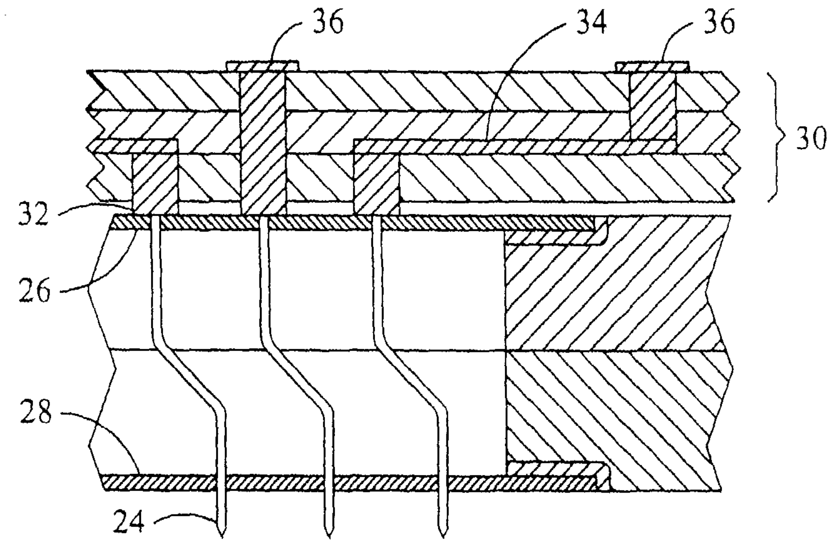


FIG. 2
(PRIOR ART)

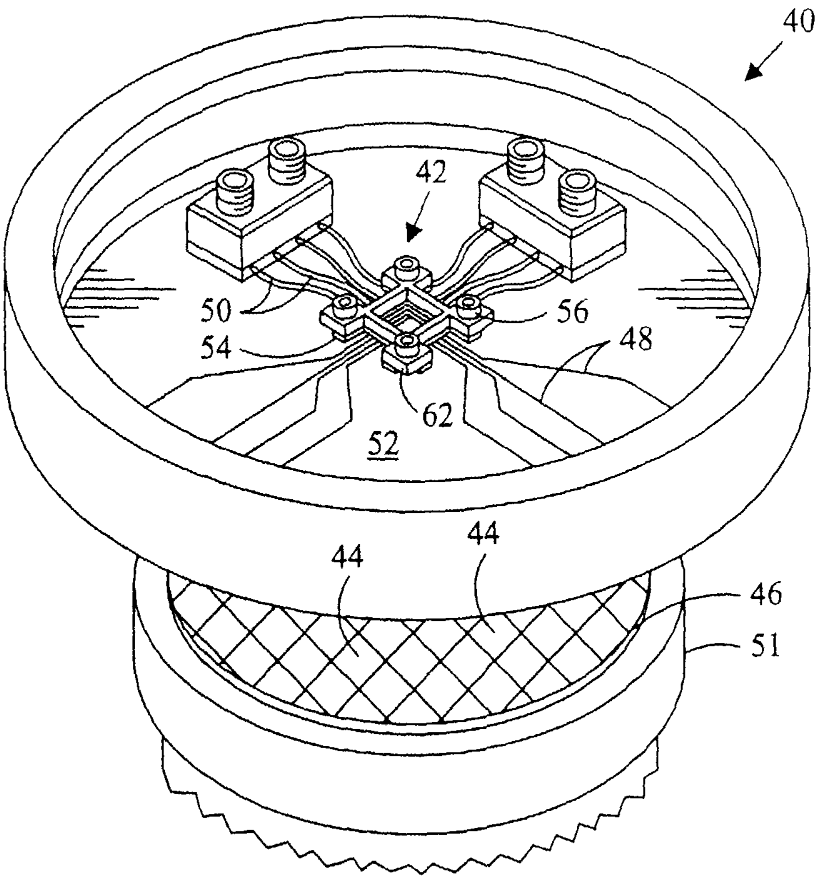


FIG. 3
(PRIOR ART)

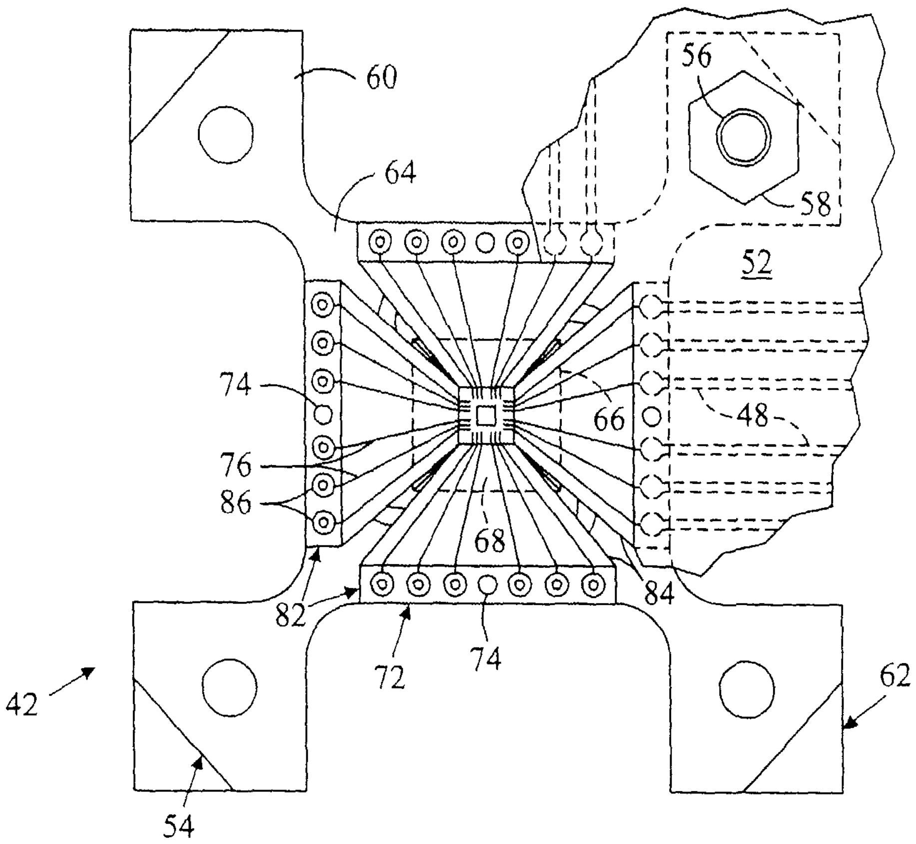


FIG. 4
(PRIOR ART)

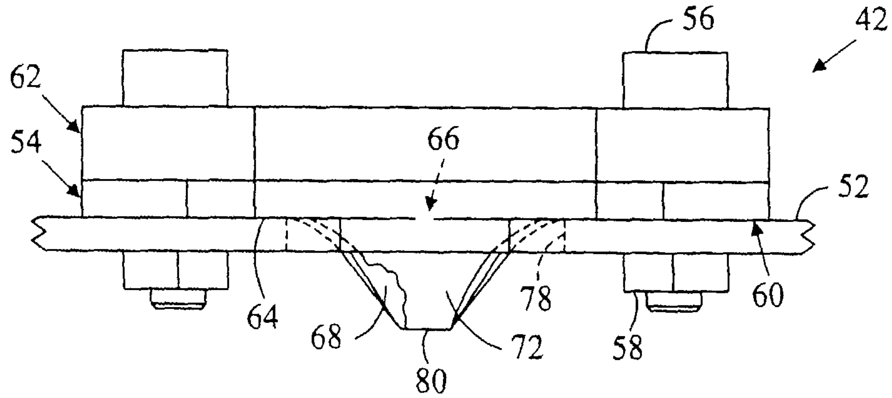


FIG. 5
(PRIOR ART)

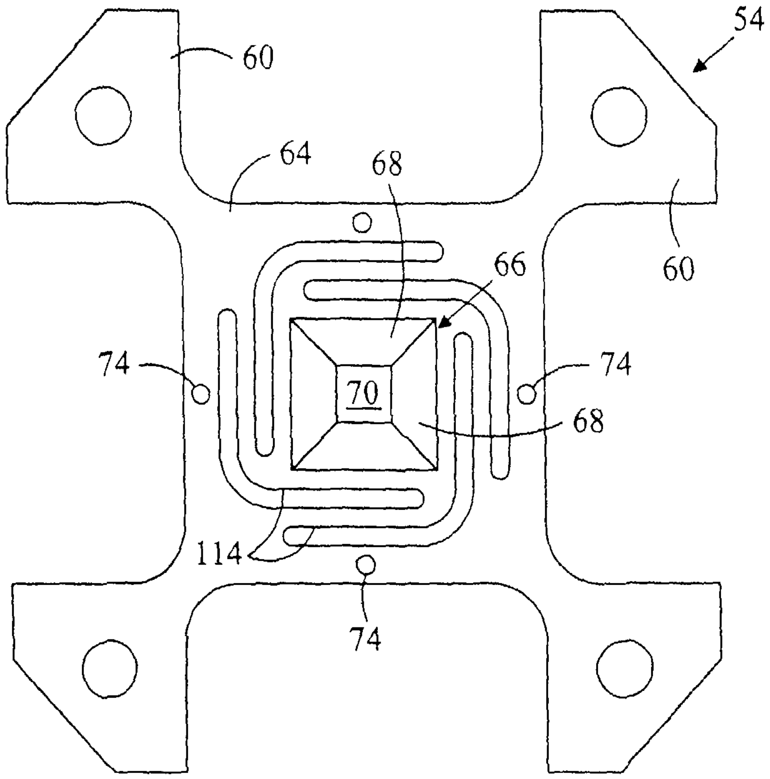


FIG. 6
(PRIOR ART)

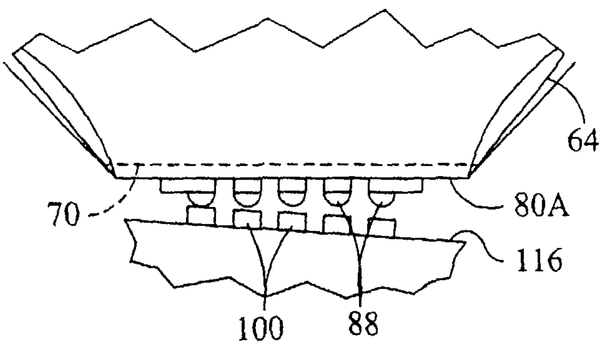


FIG. 7A
(PRIOR ART)

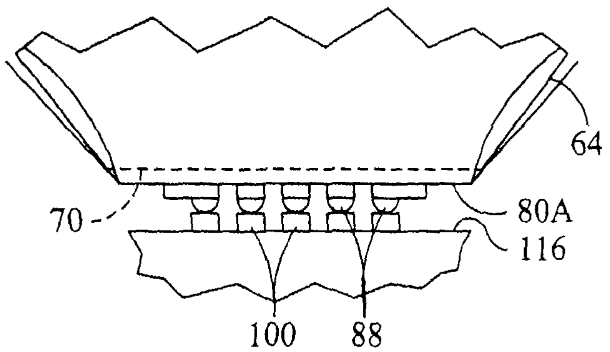


FIG. 7B
(PRIOR ART)

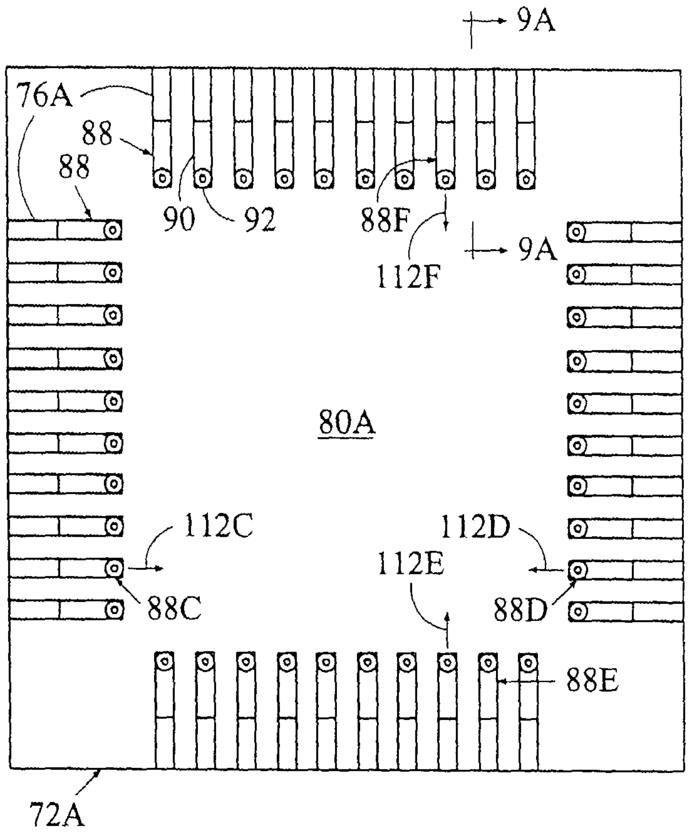


FIG. 8
(PRIOR ART)

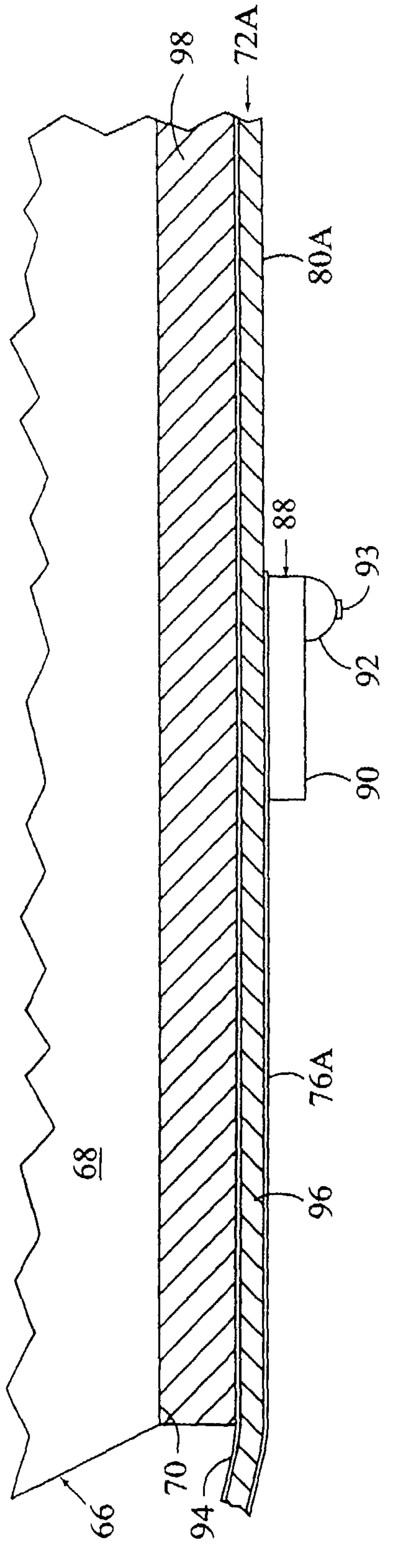


FIG. 9A
(PRIOR ART)

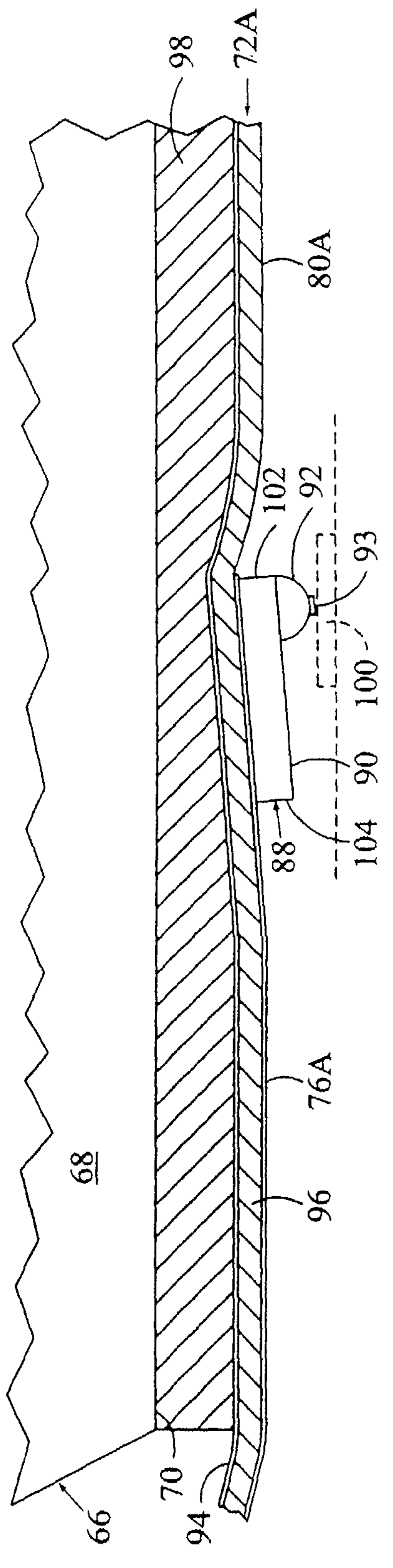


FIG. 9B
(PRIOR ART)

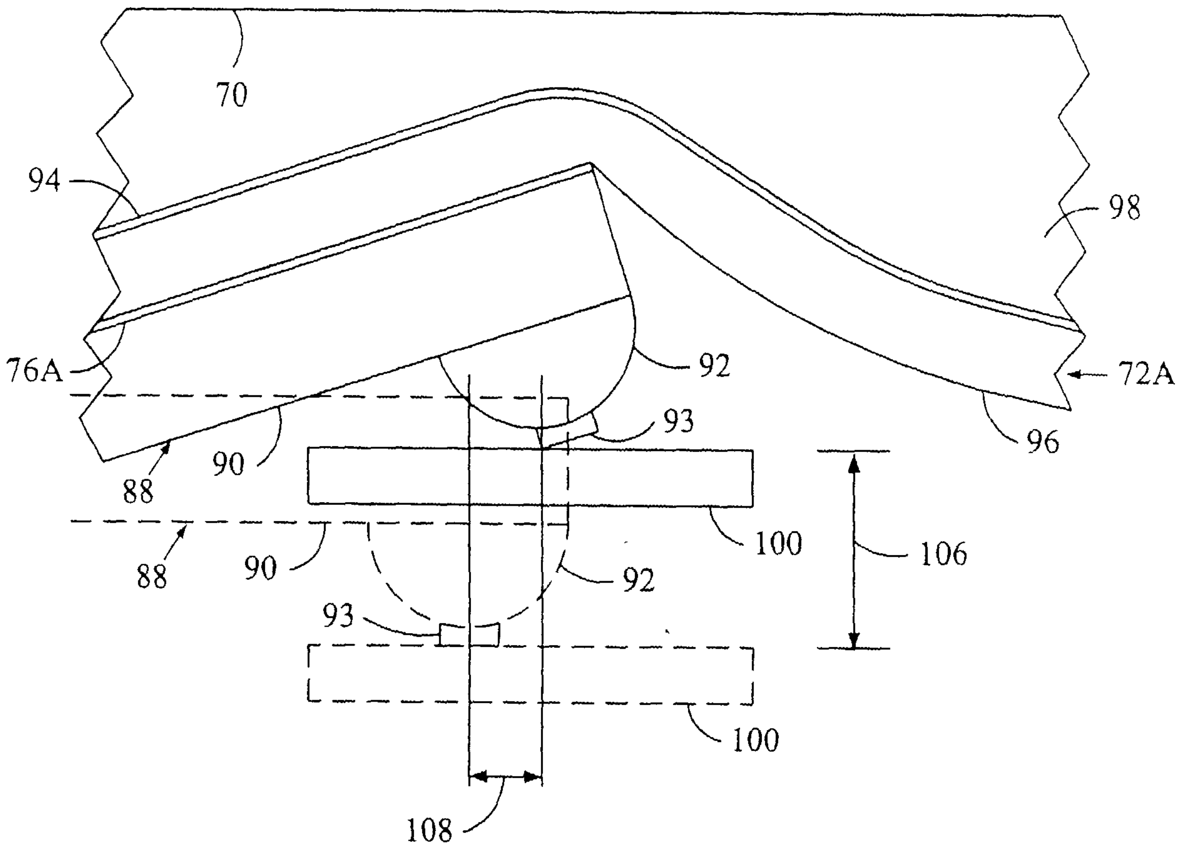


FIG. 10
(PRIOR ART)

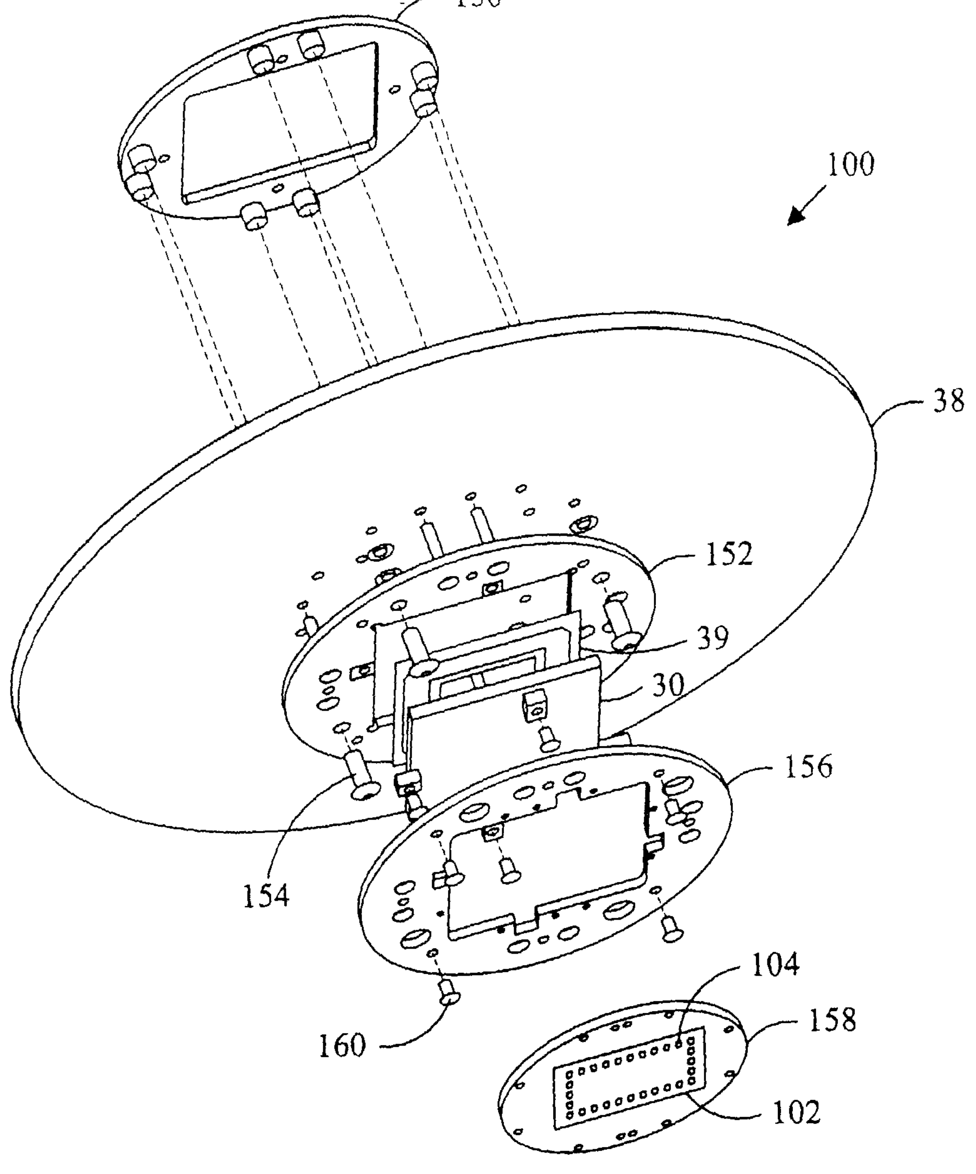
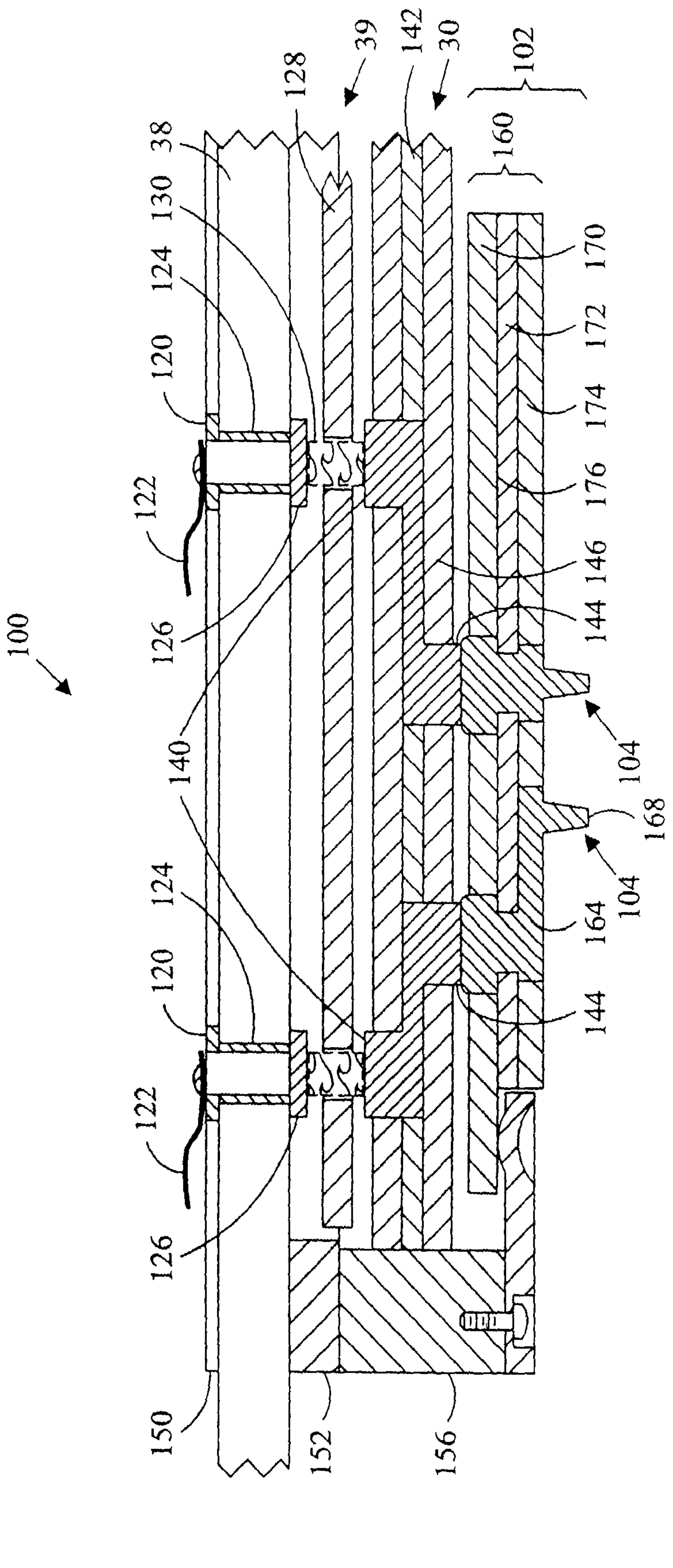


FIG. 11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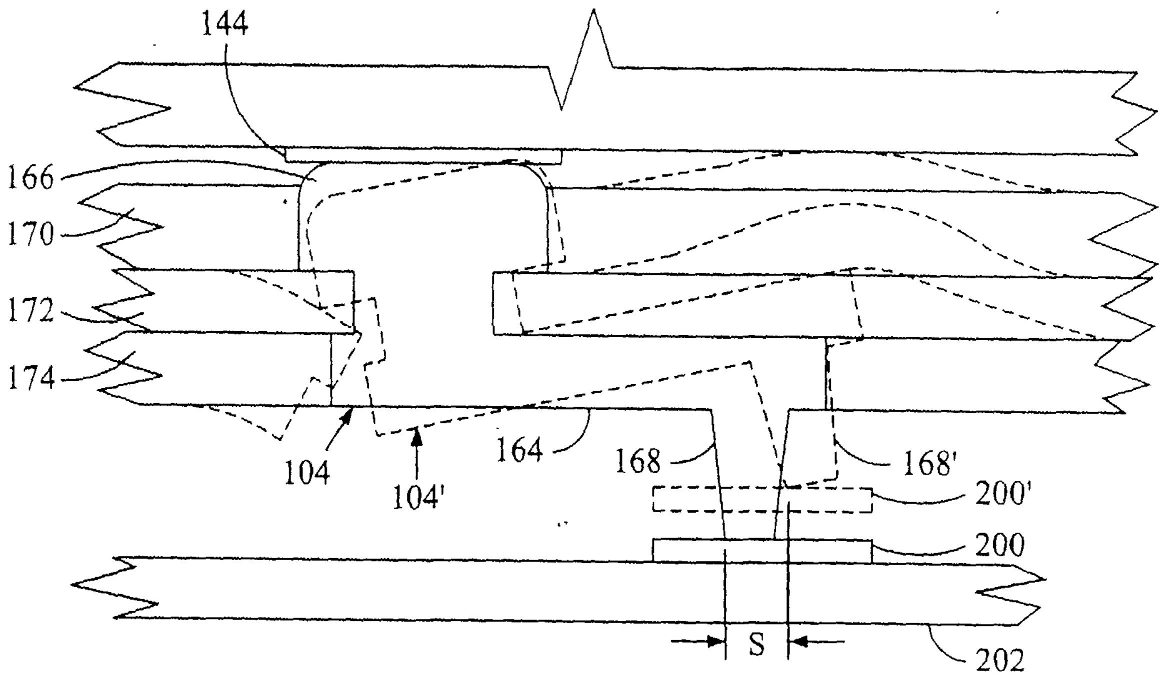
152
156

FIG. 12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170
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174
104
104'
164
168
168'
200'
200
S
202

FIG. 13

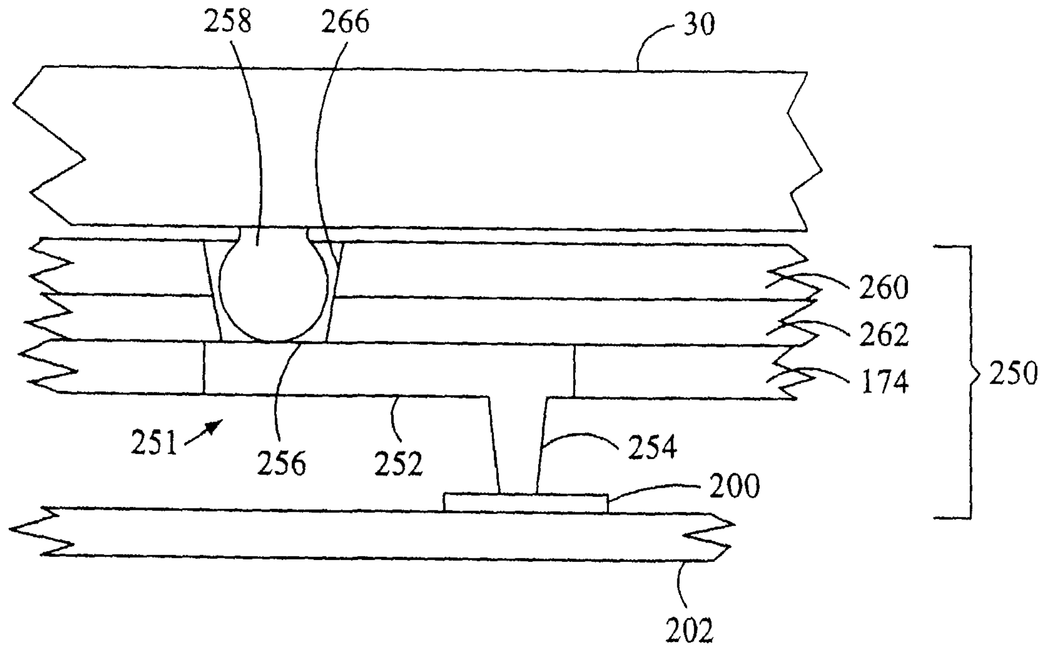
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FIG. 14

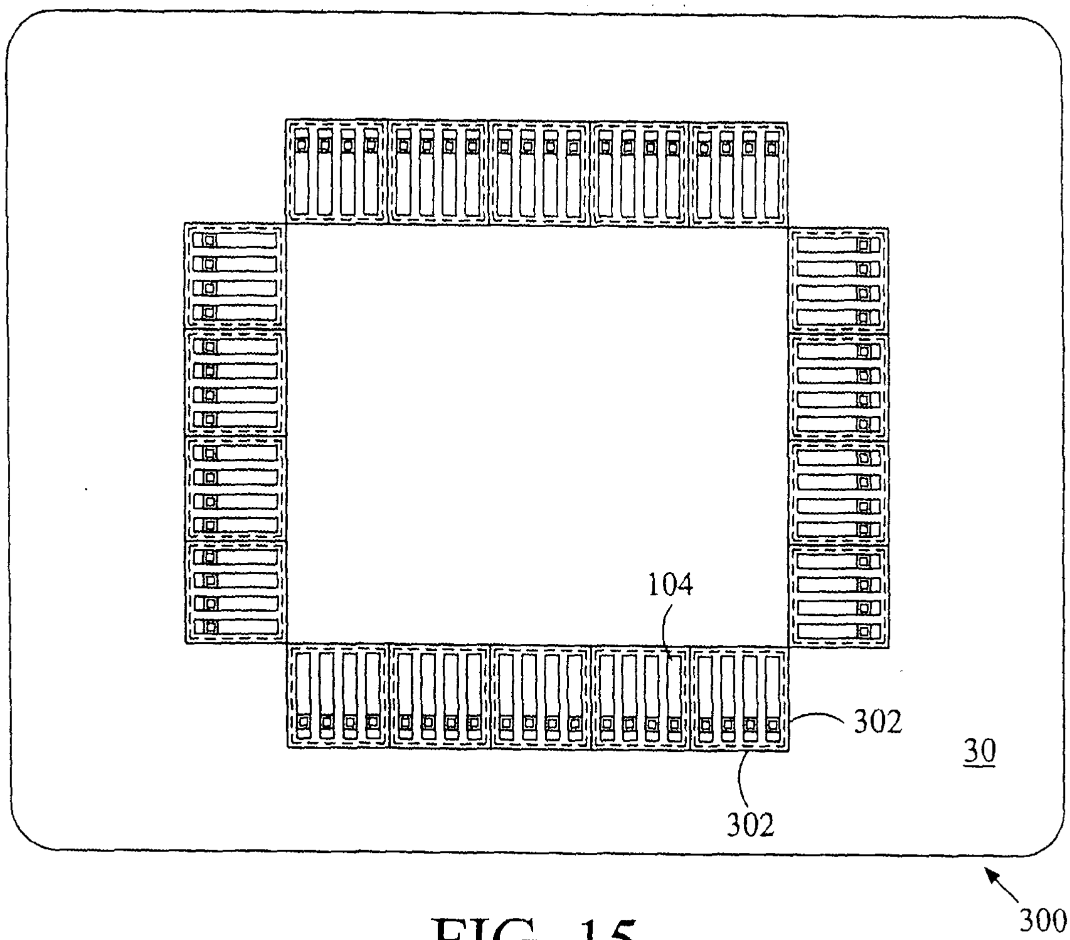

FIG. 15

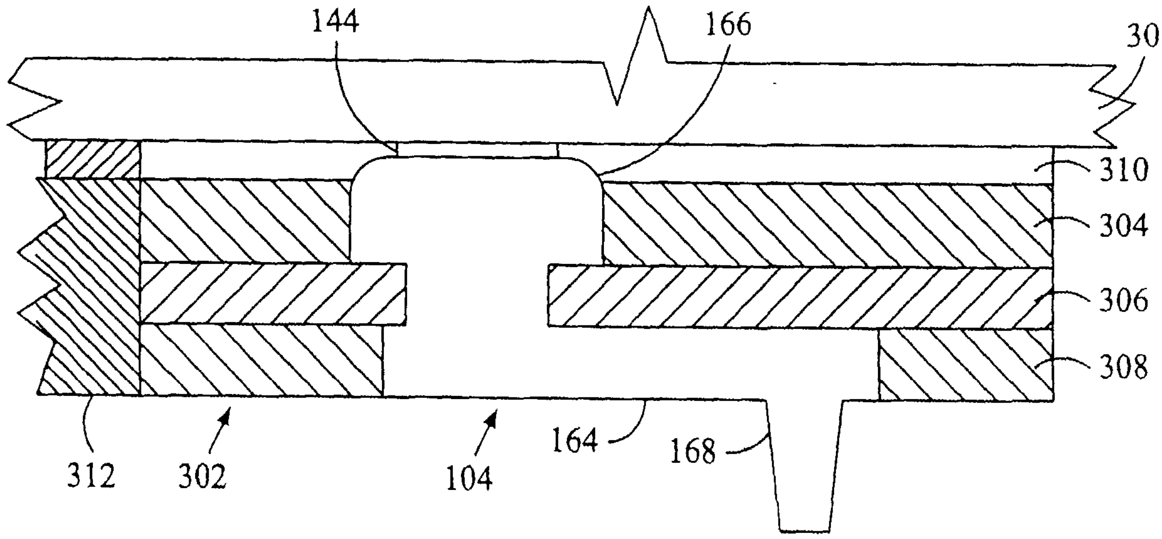

FIG. 16