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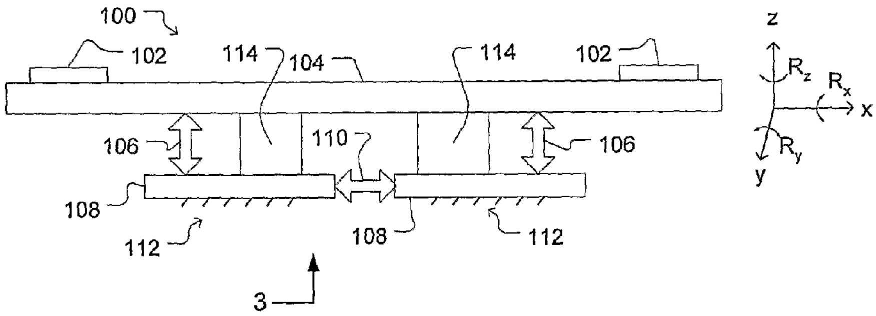
(54) **Title:** METHOD AND APPARATUS FOR ADJUSTING A MULTI-SUBSTRATE PROBE STRUCTURE



(57) **Abstract:** A probe card assembly comprises multiple probe substrates attached to a mounting assembly. Each probe substrate includes a set of probes, and together, the sets of probes on each probe substrate compose an array of probes for contacting a device to be tested. Adjustment mechanisms are configured to impart forces to each probe substrate to move individually each substrate with respect to the mounting assembly. The adjustment mechanisms may translate each probe substrate in an "x," "y," and/or "z" direction and may further rotate each probe substrate about any one or more of the forgoing directions. The adjustment mechanisms may further change a shape of one or more of the probe substrates. The probes can thus be aligned and/or planarized with respect to contacts on the device to be tested.

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METHOD AND APPARATUS FOR ADJUSTING A MULTI-SUBSTRATE PROBE STRUCTURE

BACKGROUND OF THE INVENTION

Figure 1 illustrates an exemplary probing system 90 for testing electronic devices, which may be, for example, dies (not shown) on a newly manufactured semiconductor wafer 12. The probing system 90 of Figure 1 includes a test head 4 and a prober 2 (which is shown with a cut-away 26 to provide a partial view of the inside of the prober 2). To test the dies (not shown) of the semiconductor wafer 12, the wafer 12 is placed on a moveable stage 6 as shown in Figure 1, and the stage 6 is moved such that terminals 22 on dies (not shown) of the wafer 12 are brought into contact with probes 66 of a probe card assembly 20. Temporary electrical connections are thus established between the probes 66 and dies (not shown) of the wafer 12 to be tested.

Typically, a cable 10 or other communication means connects a tester (not shown) with the test head 4. Electrical connectors 14 electrically connect the test head 4 with the probe card assembly 20, and the probe card assembly 20 includes electrical paths (not shown) to the probes 66. The cable 10, test head 4, electrical connectors 14, and probe card assembly 20 (which includes probes 66) thus provide electrical paths between the tester (not shown) and the die terminals 22 of the wafer 12 being tested. Thus, while the probes 66 are in contact with the terminals 22 of the dies (not shown) on the wafer 12, cable 10, test head 4, electrical connectors 14, and probe card assembly 20 provide a plurality of electrical paths between the tester (not shown) and the dies (not shown). The tester (not shown) writes test data through these electrical paths to the dies (not shown), and response data generated by the dies in response to the test data is returned to the tester through these electrical paths.

A typical wafer 12 comprises numerous dies (not shown). Indeed, a wafer 12 may include dozens or even hundreds of dies (not shown). Typically, probe card assembly 20 is not capable of contacting all of the dies (not shown) on a wafer 12. To test all of the dies (not shown) on a wafer 12, the stage 6 moves some of the dies (not shown) of wafer 12 into contact with the probes 66 of the probe card assembly 20, and the tester (not shown) runs tests on those dies (not shown). The stage 6 then moves the wafer 12 such that others of the dies (not shown) contacted the probes 66, and the tester (not shown) runs the same tests on those dies. This process of moving the wafer 12 to bring some of the dies (not shown) into contact with the probes 66 and testing those dies (not shown) continues until all of the dies (not shown) of the wafer 12 are tested.

As probe card assembly technology has advanced, the size of the array of probes 66 has been increased in order to contact more dies (not shown). One strategy for creating large probe arrays 66 involves using multiple probe substrates 66. That is, multiple probe substrates 66, each comprising a plurality of probes, are positioned adjacent one another so that the probes on probe substrates 66 form a large array of probes. U.S Patent No. 5,806,181, U.S. Patent No. 6,690,185, U.S. Patent No. 6,640,415, and U.S. Patent No. 6,509,751 (each of which is incorporated herein by reference in its entirety) disclose nonlimiting examples of probe card assemblies with multiple probe substrates. The probes 66 and die terminals 22, both of which are typically small, must be precisely aligned, which necessitates precise positioning of the multiple probe substrates. Methods and apparatuses for precisely positioning such probe substrates are needed.

SUMMARY OF THE INVENTION

In an exemplary embodiment, multiple probe substrates are attached to a mounting assembly. Each probe substrate includes a set of probes, and together, the sets of probes on the probe substrates compose an array of probes for contacting a device to be tested. Adjustment mechanisms are configured to impart forces to each probe substrate to move individually each substrate with respect to the mounting assembly. The adjustment mechanisms may translate each probe substrate along an "x," "y," and/or "z" axis and may further rotate each probe substrate about one or more of the forgoing axes. The adjustment mechanisms may further change a shape of one or more of the probe substrates. The probes can thus be aligned and/or planarized with respect to contacts on the device to be tested.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates an exemplary probing system for testing dies of a semiconductor wafer.

Figure 2A illustrates a side view of an exemplary probe card assembly.

Figure 2B shows a simplified electrical schematic diagram of the probe card assembly of Figure 2A.

Figure 2C shows a simplified block diagram of an exemplary implementation of the mounting assembly of the probe card assembly of Figure 2A.

Figure 3 illustrates a bottom view of the probe card assembly of Figure 2A.

Figure 4 illustrates a side view of another exemplary probe card assembly.

Figure 5 illustrates a top view of the probe card assembly of Figure 4.

Figure 6 illustrates a bottom view of the probe card assembly of Figure 4.

Figure 7 illustrates a cross-sectional side view of the probe card assembly of Figure 4.

Figure 8 illustrates another cross-sectional side view of the probe card assembly of Figure 4.

Figure 9 shows a side perspective view of a probe substrate and frame.

Figures 10A and 10B illustrate partial side views of the probe card assembly of Figure 4 showing a spring assembly.

Figures 11A and 11B illustrate partial cross-sectional side views of the probe card assembly of Figure 4 showing a differential screw assembly.

Figures 12A and 12B illustrate partial side views of the probe card assembly of Figure 4 showing a cam assembly.

Figures 13A and 13B illustrate partial bottom views of the probe card assembly of Figure 4 showing a cam assembly.

Figure 14 shows forces that can be applied to a probe substrate of the probe card assembly of Figure 4.

Figure 15 illustrates a bottom view of yet another exemplary probe card assembly.

Figure 16 illustrates a top view of the probe card assembly of Figure 15.

Figure 17 illustrates a cross-sectional side view of the probe card assembly of Figure 15.

Figures 18A-18D illustrate partial cross-sectional side views of the probe card assembly of Figure 15 showing a leveling screw assembly and a set screw.

Figure 19 shows a probe substrate of the probe card assembly of Figure 15 with attached threaded studs and partial views of the screws threaded into the studs.

Figure 20 shows forces that can be applied to a probe substrate of the probe card assembly of Figure 15.

Figure 21 shows exemplary push and pull forces that alter a shape of a probe substrate of the probe card assembly of Figure 15.

Figures 22A and 22B illustrate an exemplary lateral adjustment mechanism that may be used with the probe card assembly of Figure 15.

Figure 23 illustrates a bottom view of still another exemplary probe card assembly.

Figure 24 shows a side view of yet another exemplary probe card assembly.

Figure 25 shows a top view of the probe card assembly of Figure 24.

Figure 26 shows a bottom view of the probe card assembly of Figure 24.

Figure 27 shows a partial view from Figure 25 showing one alignment plate.

Figures 28 and 29 show cross-section side views from Figure 27.

Figure 30 shows forces that can be applied to a probe substrate of the probe card assembly of Figure 24.

Figure 31 illustrates an exemplary process for making a probe card assembly with multiple probe substrates.

DETAILED DESCRIPTION OF THE INVENTION

This specification describes exemplary embodiments and applications of the invention. The invention, however, is not limited to these exemplary embodiments and applications or to the manner in which the exemplary embodiments and applications operate or are described herein.

Figures 2A and 3 illustrate a simplified block diagram of an exemplary probe card assembly 100 that includes a plurality of probe substrates 108. (Figure 2A shows a side view and Figure 3 shows a bottom view of the probe card assembly 100.) A set of probes 112 is attached to each probe substrate 108, and the probe substrates 108 are arranged so that the probe sets 112 form a large array of probes. Although four probe substrates 108 are shown, fewer or more may be used. The probe card assembly 100 may be used in a probing system like system 90 of Figure 1 in place of probe card assembly 20, and for ease of discussion, the probe card assembly 100 will be discussed herein with regard to probing system 90.

As shown in Figures 2A and 3, the probe card assembly 100 includes connectors 102, a mounting assembly 104, and probe substrates 108 each with a set of probes 112. Connection mechanisms 114 physically connect the probe substrates 108 to the mounting assembly 104. First adjustment mechanisms 106 and second adjustment mechanisms 110 are configured to adjust the positions of the probe substrates 108 with respect to the mounting assembly 104. The depiction in Figures 2A and 3 is not necessarily in proportion. For example, the probe substrates

108 may be spaced closer together but are depicted in Figures 2A and 3 for ease of illustration.

Connectors 102 are configured to make electrical connections with a test head 4 (see Figure 1). For example, connectors 102 may be any type of electrical connector including without limitation zero insertion force ("ZIF") connectors or pogo pads for receiving pogo pin connectors.

Figure 2B shows a schematic diagram of the probe card assembly 100 in which electrical paths 152 (e.g., conductive traces and/or vias) through the mounting assembly 104, electrical connections 154 (e.g., wires, an interposer, etc.) between the mounting assembly 104 and the probe substrates 108, and electrical paths 156 (e.g., conductive traces and/or vias) through the probe substrates 108 electrically connect connectors 102 with probe sets 112.

In addition to providing electrical paths 152, the mounting assembly 104 is also configured to be securely attached to a prober 2 of a probing system like system 90 of Figure 1. For example, the mounting assembly 104 may be bolted (not shown), clamped (not shown), or otherwise secured to a prober 2.

As shown in Figure 2C, which shows a simplified block diagram of an exemplary mounting assembly 104, the mounting assembly 104 may include a stiffener plate 182 and a wiring substrate 184. The wiring substrate 184 provides the electrical paths 152 from connectors 102 (not shown in Figure 2C) through the mounting assembly 104. The wiring substrate 184 may be, for example, a printed circuit board. The stiffener plate 182 provides mechanical stiffness that resists warping, thermally induced movement, etc. The wiring substrate 184 may be secured to the prober 2 (see Figure 1), and the stiffener plate 182 may be attached to the wiring substrate 184 to stiffen the wiring substrate 184. An example is shown in Figure 5 of U.S. Patent No. Patent No. 5,974,662 in which the printed circuit board 502 is an example of a wiring substrate 184 and mounting plates 530, 532 are examples of a stiffener plate 182. Alternatively, the stiffener plate 184 may be secured to the prober 2, and the wiring substrate 184 may be attached to the stiffener plate 182. Examples are shown in Provisional Patent Application No. 60/594,562, entitled Apparatus And Method For Managing Thermally Induced Motion In A Probe Card Assembly (filed April 19, 2005). For example, the stiffener plate 202 shown throughout the drawings in Provisional Patent Application No. 60/594,562 is an example of stiffener plate 182, and wiring substrate 204 also shown throughout the drawings in Provisional Patent Application No. 60/594,562 is an example of wiring substrate 184. The aforementioned U.S. Patent No. Patent No. 5,974,662 and Provisional Patent Application No. 60/594,562 are incorporated herein by reference in their entirety.

The attachment mechanisms 114, which are represented generically as boxes in Figure 2A, are, as mentioned above, configured to physically connect the probe substrates 108 to the mounting assembly 104. Preferably, the attachment mechanisms 110 physically connect the probe substrates 108 to the stiffener plate 182 portion of the mounting assembly 104. In addition, the attachment mechanisms 114 may be configured to bias the probe substrates 108 in particular directions. In the example shown in Figure 3, the probe substrates 108 are biased in the directions of arrows 116, which as shown in Figure 3, biases each probe substrate 108 away from the other probe substrates. As an example of an alternative biasing arrangement, one probe substrate 108 may not be biased in any direction but may act as a reference away from which each of the other probe substrates 108 is biased. For example, the probe substrate 108 located in the lower right corner of Figure 3 may alternatively not be biased in any direction, while each of the other three probe substrates is biased away from the other probe substrates in the direction of arrows 116.

Each probe substrate 108 comprises a platform for a probe set 112 and includes electrical paths 156 (see Figure 2B) through the probe substrate 108 to probes 112. A probe substrate 108 may comprise, for example, a ceramic or an organic substrate with conductive traces (not shown) and conductive vias (not shown) forming electrical paths 156.

Probes 112 may be a resilient, conductive structure. Nonlimiting examples of suitable probes 112 include composite structures formed of a core wire bonded to a conductive terminal (not shown) on a probe substrate 108 that is over coated with a resilient material as described in U.S. Patent No. 5,476,211, U.S. Patent No. 5,917,707, and U.S. Patent No. 6,336,269, all of which are incorporated in their entirety herein by reference. Probes 112 may alternatively be lithographically formed structures, such as the spring elements disclosed in U.S. Patent No. 5,994,152, U.S. Patent No. 6,033,935, U.S. Patent No. 6,255,126, U.S. Patent Application Publication No. 2001/0044225, and U.S. Patent Application Publication No. 2001/0012739, each of which is also incorporated in its entirety herein by reference.

Other nonlimiting examples of probes 112 include conductive pogo pins, bumps, studs, stamped springs, etc.

First adjustment mechanisms 106 and second adjustment mechanisms 110 allow the position of each probe substrate 108 to be changed with respect to the mounting assembly 104. Because the mounting assembly 104 is securely attached to the prober 2, the position of each probe substrate 108 is also changed with respect to the prober 2 and the wafer 12 to be tested (see Figure 1) that is disposed on the stage 6 (see Figure 1). The probes 112 can thus be aligned and/or planarized with the die terminals 22.

Preferably, the first adjustment mechanisms 106 and the second adjustment mechanisms 110 are configured to impart six degrees of movement to each probe substrate 108. In Figure 2A, those six degrees of movement are labeled as follows: the horizontal direction across the page of Figure 2A is labeled "x," the horizontal direction into and out of the page of Figure 2A is labeled "y," the vertical direction is labeled "z," rotation about the "x" axis is labeled R_x, rotation about the "y" axis is labeled R_y, and rotation about the "z" axis is labeled R_z. The forgoing directions are provided for ease of discussion and are not limiting.

The first adjustment mechanisms 106 are configured to move one or more portions of a probe substrate 108 in the "z" direction. The first adjustment mechanisms 106 are thus able to move each probe substrate 108 in three degrees of motion: translation along the "z" axis, rotation R_x about the "x" axis, and rotation R_y about the "y" axis. The second adjustment mechanisms 110 are configured to move one or more portions of a probe substrate 108 in the "x, y" plane. The second adjustment mechanisms 110 are thus able to move each probe substrate 108 in three additional degrees of motion: translation along the "x" axis, translation along the "y" axis, and rotation R_z about the "z" axis.

Figures 4-8 illustrate an exemplary probe card assembly 400 in which each of the attachment mechanisms 114 of Figures 2A and 3 comprises a frame 410 and spring assemblies 408, each of the first adjustment mechanisms 106 comprises differential screws 404, and each of the second adjustment mechanisms 110 comprises cam assemblies 406. As shown, the probe card assembly 400 also includes connectors 102, mounting assembly 104, probe substrates 108, and probes 112 as in Figures 2A and 3. (For ease of illustration, the depictions in Figure 4-8 are not necessarily in proportion. For example, the probe substrates 108 may be spaced closer together but are depicted in Figures 4-8 for ease of illustration.)

As mentioned above, an attachment mechanism 114 of Figures 2A and 3 is implemented in probe card assembly 400 as a frame 410 and spring assemblies 408. As shown in Figures 4 and 6, a plurality of spring assemblies 408 attaches a frame 410 to the mounting assembly 104. Figure 9 shows an elevated, perspective view of an exemplary frame 410, which includes open spaces 802. A probe substrate 108 is attached to the frame 410, which attachment may be effected with bolts, clamps, glue, an adhesive, etc. As shown in Figure 8, which shows a side, cross-sectional view of the probe card assembly 400, an interposer 804 fits within each of the spaces 802 of the frame 410. As also shown in Figure 8, each interposer 804 preferably comprises a first set of electrically conductive spring elements 808 for contacting the mounting assembly 104 and a second set of electrically conductive spring elements 810 for contacting the probe substrate 108. The first set of spring contact elements 808 is electrically connected through the interposer substrate 806 to the second set of spring contact elements 810. Each interposer 804 thus provides the electrical paths 154 (see Figure 2B) between the mounting assembly 104 and the probe substrates 108, and because contact elements 808, 810 are springs, those electrical paths 154 are compliant (i.e., the electrical paths 154 remain established even as the position of a probe substrate 108 with respect to the mounting assembly 104 is changed by cam assemblies 406 and differential screw assemblies 404). Contact elements 808, 810 may be constructed like probes 112, as discussed above. The interposer 504 in Figure 5 of the aforementioned U.S. Patent No. 5,974,662 and interposer 230 in Figure 2A of U.S. Patent 6,509,751 (which is incorporated herein in its entirety by reference) are nonlimiting examples of suitable interposers 804. Although spaces 802 in each frame 410 are provided for four interposers 804 per probe substrate 108, fewer or more interposers 804 per probe substrate 108 may be used.

As shown in Figure 6 (which shows a bottom view of the probe card assembly 400), each frame (which is hidden behind probe substrates 108 in Figure 6) is attached to the mounting assembly 104 by a plurality of spring assemblies 408. Figures 10A and 10B show detailed side and front views, respectively, of one such spring assembly 408. As shown in Figures 10A and 10B, the spring assembly 408 includes a pin 1002 attached to the mounting assembly 104 and a pin 1006 attached to the frame 410. (The mounting assembly 104, frame 410, and probe substrate 108 are shown in partial view in Figures 10A and 10B.) Frame pin 1006 may be integrally formed with frame 410 or, alternatively, frame pin 1006 may be threaded or wedged into a hole (not shown) in the frame 410. Assembly pin 1002 may be similarly integrally formed with the mounting assembly 104 or threaded or wedged into a hole (not shown) in the mounting assembly 104. Alternatively, pin 1002 and pin 1006 may be glued, welded, adhered, brazed, soldered, or otherwise attached to the mounting assembly 104 and the frame 410, respectively.

Spring 1004 is attached to both the assembly pin 1002 and the frame pin 1006. The spring 1004 may be any suitable spring structure and may be attached to the assembly pin 1002 and the frame pin 1006 in any suitable manner (e.g., the ends of the spring 1004 may be secured in holes (not shown) in the pins 1002, 1006, the ends of the spring 1004 may be wrapped around pins 1002, 1006, etc.).

The spring assembly 408 not only attaches the frame 410 to the mounting assembly 104, the spring assembly 408 also biases the probe substrate 108. With regard to Figure 10A, the spring assembly 408 biases the probe substrate 108 (which is attached to the frame 410) upward and into the page, as shown by arrows 1010 in Figure 10A. In Figure 10B, which shows a side view of Figure 10A, the directions of bias are upward and to the left, as shown by arrows 1010. By selective placement of the spring assemblies 408, the probe substrates 108 may be biased in any desired directions. For example, the placement of spring assemblies 408 on probe card assembly 400 as shown in Figure 6 (which shows a bottom view of the probe card assembly 400) biases the four probe substrates 108 shown in Figure 6 away from each other (similar to direction arrows 116 in Figure 3) and toward the mounting assembly 104.

As mentioned above and shown in Figure 7, the first adjustment mechanisms 106 of Figures 2A and 3 are implemented in probe card assembly 400 of Figures 4-8 as a plurality of differential screw assemblies 404 and corresponding pivot spheres 1106. Figure 11A shows a detailed cross-sectional view of one such differential screw assembly 404 and corresponding pivot sphere 1106. (Figure 11A shows the mounting assembly 104, frame 410, and probe substrate 108 in partial view.) As shown, the differential screw assembly 404 includes an outer threaded element 1104 that is firmly and immovably secured to the mounting assembly 104. A screw 1102 threads into the outer element 1104. As shown in Figure 11B, as the screw 1102 is rotated 108 in one direction, it moves downward against the pivot sphere 1106, which is disposed in a recess 902 in the frame 410, pushing the frame 410 (and thus also the probe substrate 108) away from the mounting assembly 104. Rotating the screw 1102 in the opposite direction (not shown), retracts the screw 1102 away from the pivot sphere 1106, and the spring action of the spring assemblies 408 (which, as discussed above, bias the frame 410 toward the mounting assembly 104) moves the frame 410 with the screw 1102.

As shown in Figure 9, frame 410 has nine recesses 902 for nine pivot spheres 1106 (not shown in Figure 9) and is thus configured to be moved by nine differential screw assemblies 404. (Figure 7, which shows a cross-sectional side view of the probe card assembly 400, shows three such differential screw assemblies 404 for each of two frames 410 that are shown in Figure 7.) As shown in Figure 14, the nine differential screw assemblies 404 bring nine forces 1406 to bear against a frame 410 (shown in block diagram form in Figure 14), and by selective application of each of those nine forces 1406, the frame 410 (and thus the probe substrate 108 (not shown in Figure 14) attached to the frame can be translated along the "z" axis and rotated (R_x, R_y) about both the "x" and "y" axes. Of course, however, fewer or more than nine differential screw assemblies 404 may be used to adjust one probe substrate 108.

As mentioned above, the second adjustment mechanism 110 of Figures 2A and 3 is implemented in probe card assembly 400 of Figures 4-8 as a plurality of cam assemblies 406. Figure 12A shows a side view and Figure 13A shows a bottom view of one such cam assembly 406. As shown, a cam 1204 is firmly attached to a screw 1202, which is threaded into a threaded opening (not shown) in a post 1206. The post 1206 is firmly attached to the mounting assembly 104. Rotation of the screw 1202 rotates the cam 1204. As shown in Figures 12B and 13B, the cam 1204 abuts against the frame 410, and as the cam 1204 is rotated 1308 in one direction, the cam 1204 pushes against and moves 1210 the frame 410. As the cam 1204 is rotated in the opposite direction (not shown), the cam 1204 moves away from the frame 410, and the spring action of the spring assemblies 408 (which, as discussed above, bias the frame 410) pushes the frame 410 with the cam 1204.

As shown in Figures 4 and 6, eight cam assemblies 406 are positioned around each frame 410 (in Figure 6, a frame 410 is hidden under each probe substrate 108). As shown in Figure 14, the eight cam assemblies 408 bring eight forces 1404 to bear against a frame 410 (shown in block diagram form in Figure 14), and by selective application of each of those eight forces 1404, the frame 410 (and thus the probe substrate 108 attached to the frame) can be translated along the "x" and "y" axes and rotated (R_z) about the "z" axis. Of course, however, fewer or more than eight cam assemblies 406 may be used to adjust one probe substrate 108. For example, a cam assembly 406 need not be located along every side of a probe substrate 108. For example, cam assemblies 408 may be located only on sides of a probe substrate108 where the cam assemblies 408 oppose biasing directions of the spring assemblies 408.

Figures 15-17 illustrate another exemplary probe card assembly 1500. Figure 15 shows a bottom view, Figure 16 shows a top view, and Figure 17 shows a side, cross-sectional view of the probe card assembly 1500. For ease of illustration, the depictions in Figure 15-17 are not necessarily in proportion. For example, the probe substrates 108 may be spaced closer together but are depicted in Figures 15-17 for ease of illustration. Probe card assembly 1500 is, in some ways, similar to probe card assembly 400.

Like probe card assembly 400, probe card assembly 1500 may be used in a probing system. For example, probe card assembly 1500 may be used in place of the probe card assembly 20 in the probing system 90 of Figure 1. In addition, the probe card assembly 1500 includes connectors 102 and a mounting assembly 104, which may be the same as like named and numbered elements in probe card assembly 400. Also, like probe card assembly 400, probe card assembly 1500 includes a plurality of probe substrates 108 (four are shown, although fewer or more may be used) arranged so that the probe sets 112 on each probe substrate 108 together form a large array of probes.

In the probe card assembly 1500, however, the attachment mechanism 114 of Figures 2A and 3 is implemented by leveling screw assemblies 1504. The first adjustment mechanism 106 of Figures 2A and 3 is also implemented by the leveling screw assemblies 1504, and the second adjustment mechanism 110 of Figures 2A and 3 is implemented by the leveling screw assemblies 1504 and set screws 1506 in bracket 1510. Exemplary spring assemblies 1508, which are shown in Figures 15 and 17, are in compression. Each spring assembly 1508 shown in Figure 15 therefore biases the two probe substrates 108 to which the spring assembly 1508 is attached away from each other. Spring assemblies 1508 may be generally similar structurally to spring assemblies 408 in probe card assembly 400 but attached to between to probe substrates 108 rather than between frame 410 and mounting assembly 104.

As shown in particular in Figure 17, the probe substrates 108 are attached to the mounting assembly 104 by leveling screw assemblies 1504, each of which extends through a passage 1702 in the mounting assembly 104. As illustrated in Figure 18A, which shows a detailed view of the left-most leveling screw assembly 1504 in Figure 17, each leveling screw assembly 1504 includes a screw 1802, a locking nut 1804, and a threaded stud 1806. The threaded stud 1806 is attached to a probe substrate 108. The method of attaching the threaded stud 1806 to the probe substrate 108 is not important, and any method may be used, including without limitation, any of the following methods: weld, braze, glue, adhesives, etc. The leveling screw assemblies 1504 attach the probe substrates 108 to the mounting assembly 104 and thus are another example of an attachment mechanism 114 of Figure 2A.

As shown in Figure 18A, the shaft 1803 of the screw 1802 is threaded into a threaded hole (not shown) in stud 1806. As shown in Figure 18B, as the screw 1802 is rotated 1858 in one direction, the screw 1802 retracts and exerts a pulling force on the stud 1806 and thus also on the probe substrate 108, which moves 1860 the probe substrate 108 towards the mounting assembly 104. As the screw 1802 is rotated 1858 in the opposite direction, the screw 1802 advances and exerts a pushing force on the stud 1806 and thus also on the probe substrate 108, which moves 1860 the probe substrate 108 away from the mounting assembly 104. The leveling screw assemblies 1504 thus move the probe substrate 108 to which they are attached vertically (relative to Figures 18A-18D). The leveling screws 1504 are thus also another example of the first adjusting mechanism 106 in Figure 2A.

As shown in Figure 18C, passages 1702 in the mounting assembly 104 are sufficiently large to allow the screw 1802 to move 1850 laterally in the passage 1702. While the locking nut 1804 is in a disengaged position (shown in Figure 18C), the leveling screw assembly 1504 can be moved 1850 laterally (relative to Figures 18A-18D), which as shown in Figure 18C, also moves 1850 the probe substrate 108 to which the threaded stud 1806 is attached. Passage 1702 is preferably configured so that lateral movement 1850 includes movement in any direction in the plane of the probe substrate 108 (e.g., the "x, y" plane shown in Figure 2A.) While the locking nut

1804 is in an engaged position (shown in Figure 18A), the leveling screw assembly 1504 is locked into position and cannot move 1850 laterally within passage 1702.

As shown in Figure 18D, a set screw 1506 is threaded through a threaded hole (not shown) in a bracket 1510, which is attached to the mounting assembly using any suitable means (e.g., bolts, screws, clamps, glue, adhesives, etc.). Rotation 1854 of the set screw 1854 in one direction advances the screw 1854 towards the probe substrate 108, pushing 1856 the probe substrate laterally. Rotation 1854 of the screw 1854 in the opposite direction retracts the screw 1854 away from the probe substrate 108. Because of the biasing effects of springs 1508 (not shown in Figure 18D), the probe substrate 108 moves with the set screw 1506 as the set screw is retracted. (As discussed above, the exemplary springs 1508 are preferably in compression and therefore, configured as shown in Figures 15 and 17, apply forces to a probe substrate 108 that are in opposition to forces applied to the probe substrate 108 by the set screws 1506.) The shaft 1803 of screw 1802 preferably flexes, as shown in Figure 18D, to allow movement of the probe substrate 108 while locking nut 1804 is locked, which as discussed above, prevents the leveling screw assembly 1504 from moving laterally within passage 1702. Alternatively, the shaft 1803 of the screw 1802 of in the leveling screw assembly 1504 may be resilient (i.e., spring like) so that the shaft 1803 exerts a counterforce on the probe substrate 108 in opposition to the force imparted by the set screw 1506 on the probe substrate 108. Such resilient shafts 1803 may also be configured to, during initial assembly of a probe card assembly 1500, bias the probe substrates 108 away from each other. If shafts 1803 are resilient, springs 1508 need not be used. As yet another alternative, springs 1506 and resilient shafts 1803 may both be used.

As discussed above, both the leveling screw assemblies 1504 and the set screw 1506 are able to effect lateral movement 1856 (relative to Figure 18D) of the probe substrate 108. In a preferred embodiment, movement of the leveling screw assemblies 1504 within passages 1702 is for coarse lateral adjustment of the probe substrates 108, and the set screws 1506 are used for fine lateral adjustment of the probe substrates 108. The leveling screw assemblies 1504 and the set screws 1506 are thus another example of the second adjusting mechanism 110 in Figure 2A.

As shown in Figure 19, each exemplary probe substrate 108 has nine threaded studs 1806 into which are threaded nine shafts 1803 (shown in partial view in Figure 19) of the screws 1802 of leveling screw assemblies 1504. (Of course, however, fewer or more than nine leveling screw assemblies 1504 may be used to adjust one probe substrate 108.) As shown in Figure 20, the nine leveling screw assemblies 1504 bring nine forces 2006 to bear against a probe substrate 108, and by selective application of each of those nine forces 2006, the probe substrate 108 can be translated along the "z" axis and rotated (R_x, R_y) about both the "x" and "y" axes. As shown in Figure 21, because the leveling screw assemblies 1504 can impart a push or a pull force to the probe substrate 108, the leveling screw assemblies 1504 are further able to change a shape of the probe substrate 108 and thus correct for such things as bending or bowing of the probe substrate 108. In Figure 21, which shows a side view of Figure 20, alternating push and pull forces are applied to the probe substrate 108, which changes the shape of the surface 1902 of the probe substrate 108 to which the probes (not shown in Figure 21) are attached. The degree by which the shape of surface 1902 is altered in Figure 21 is exaggerated for purposes of illustration. Typically, the surface 1902 is altered only slightly to compensate for minor imperfections in the planarity of the surface 1902 or the die terminals 22 (see Figure 1). The aforementioned U.S. Patent No. 6,509,751 discloses and discusses examples in which the shape of a probe substrate is altered.

As best seen in Figure 15, four set screws 1506 are positioned around each probe substrate 108 in the probe card assembly 1500. As shown in Figure 20, the four set screws 1506 bring four forces 2004 to bear against a probe substrate 108, and by selective application of each of those four forces 2004 (and selective lateral movement of leveling screw assemblies 1504 as shown in Figure 18C), the probe substrate 108 can be translated along the "x" and "y" axes and rotated (R_z) about the "z" axis. Of course, however, fewer or more than four set screws 1506 may be used to adjust one probe substrate 108.

Referring again to Figure 17, wires 1704 provide electrical paths 154 (see Figure 2B) between the mounting assembly 104 and the probe substrates 108. Each wire 1704 may be attached (e.g., soldered) at one end to a conductive terminal (not shown) on the mounting assembly 104 and at the other end to a conductive terminal (not shown) on a probe substrate 108. The wires 1704 may be flexible to accommodate movement of the probe substrates 108.

Figure 22A illustrates an exemplary lateral adjustment assembly 2202 that may be used in place of the cam assemblies 406 of probe card assembly 400 or the set screws 1506 in probe card assembly 1500. As shown, the assembly 2202 includes a differential screw structure comprising a threaded screw 2204 whose shaft 2208 threads through a threaded hole (not shown) in an outer element 2206 that is embedded, attached to, integrally formed with, or otherwise secured to the mounting assembly 104. The shaft 2208 presses against a sphere 2210 disposed between receiving structures 2212 disposed on adjacent probe substrates 108. A spring 2214 exerts forces that tend to pull the probe substrates together (e.g., spring 2214 is in tension).

As shown in Figure 22B, as the screw 2204 is rotated 2250 in one direction, the shaft 2208 advances, pushing the sphere 2210 towards the probe substrates 108 and moving 2252 the probe substrates 108 apart laterally. As the screw 2204 is rotated 2250 in the opposite direction, shaft 2208 retracts away from the sphere 2210, and spring 2214 pulls the probe substrates 108 towards each other.

The lateral adjustment assembly 2202 shown in Figure 22A is thus another example of the second adjustment mechanism 110 of Figures 2A and 3. The lateral adjustment assembly 2202 of Figure 22A may be particularly useful in a probe card assembly in which at least one of the probe substrates 108 is surrounded by other probe substrates 108. An example of such a probe card assembly 2300 is shown in Figure 23 (which shows a bottom view of the probe card assembly 2300). As shown, the probe card assembly 2300 includes nine probe substrates 108, each with a probe set 112. Because the middle probe substrate 108 is surrounded by other probe substrates 108, the use of adjustment assemblies 2202, whose adjustment mechanism (screw 2204) is accessible from the other side of the mounting assembly 104, may be more convenient than assemblies whose adjustment mechanisms are located lateral to the probe substrates (e.g., the set screws 1506 in probe card assembly 1500). (For ease of illustration, the depiction in Figure 23 is not necessarily in proportion. For example, the probe substrates 108 may be spaced closer together but are depicted in Figure 23 for ease of illustration.)

Figures 24-26 illustrate yet another exemplary probe card assembly 2400. Figure 24 shows a side view, Figure 25 shows a top view, and Figure 26 shows a bottom view of the probe card assembly 2400. For ease of illustration, the depictions in Figure 24-26 are not necessarily in proportion.

Probe card assembly 2400 is, in some ways, similar to probe card assembly 1500. Like probe card assembly 1500, probe card assembly 2400 may be used in a probing system. For example, probe card assembly 2400 may be used in place of the probe card assembly 20 in the probing system 90 of Figure 1. In addition, the probe card assembly 2400 includes connectors (not shown but similar to connectors 102 in probe card assembly 1500) and a mounting assembly 104, which may be the same as the mounting assembly 104 in probe card assembly 1500. A shown in Figure 24, the mounting assembly 104 preferably includes a stiffener plate 182 and a wiring board 184 as shown in and discussed with respect to Figure 2C. Also, like probe card assembly 1500, probe card assembly 2400 includes a plurality of probe substrates 108 (four are shown, although fewer or more may be used) arranged so that the probe sets 112 on each probe substrate 108 together form a large array of probes. Like probe card assembly 400 of Figures 4-6, probe card assembly 2400 includes interposers 804 (each comprising spring contact elements 806 and 810 and an interposer substrate 806 as shown in Figure 8) for providing flexible and/or resilient electrical connections between the wiring substrate 184 and the probe substrates 108, as discussed above with respect to Figure 8. Interposers 804 may, alternatively, be replaced with other flexible electrical connections such as the flexible wires 1704 shown in Figure 17.

In the probe card assembly 2400, however, the attachment mechanism 114, first adjustment mechanism 106, and second adjustment mechanism 110 of Figures 2A and 3 are implemented by alignment plates 2402 and alignment/planarization ("AP") assemblies 2408. As shown, in probe card assembly 2400, there is one alignment plate 2402 for each probe substrate 108, and there are nine AP assemblies 2408 per alignment plate 2402. Of course, however, more or fewer alignment plates 2402 per probe substrate 108 and AP assemblies 2408 per alignment plate 2402 may be used.

Figures 27-29 show a detailed illustration of one of the four alignment plates 2402. Figure 27, which is a partial view of Figure 25, shows a top view of one alignment plate 2402, and Figures 28 and 29 show side, cross-sectional views of the alignment plate 2402 of Figure 27. All four of the alignment plates 2402 of probe card assembly 2400 may be similarly configured.

The alignment plate 2402, which may be a metallic substrate, includes openings 2714 for accessing each AP assembly 2408 and tool passages 2710. (Although four tool passages 2710 are shown, fewer or more may be used.) As shown, in Figure 27, nine AP assemblies 2408 are attached to an alignment plate

2402. (As stated above, more of fewer than nine AP assemblies 2408 may be used.)

As best seen in Figure 29, each AP assembly 2408 comprises a housing 2712 and a differential screw assembly 2708 that includes a stud extender 2804 that threads into a stud 2806 attached to a probe substrate 108. The differential screw assemblies 2708 are preferably of a split-nut configuration. The differential screw assemblies 2708 may function generally like the leveling screw assemblies 1504 of probe card assembly 1500. That is, like leveling screw assemblies 1504, differential screw assemblies 2708 can exert a pushing or pulling force on the threaded stud 2806. Similar to the movement shown in Figure 18B, rotation of the differential screw assembly 2708 in one direction pulls the stud 2806 (and thus the probe substrate 108) towards the mounting assembly 104, and rotation of the differential screw assembly 2708 in the opposite direction pushes the stud 2806 (and thus the probe substrate 108) away from the mounting assembly 104. Split-nut differential screws that provide for fine adjustments on the order of 10 microns or less, and such precise split-nut differential screws may be used. A tool (not shown) may engage the differential screw assemblies 2708 through openings 2714.

As also best seen in Figure 29, the housing 2712 is located between the alignment plate 2402 and the stiffener plate 182 of the mounting assembly 104. (The housing 2712 is located behind the alignment plate 2402 and thus out of view in Figure 27. Nevertheless, for ease of illustration, the housing 2712 is included in Figure 27 but is shown in dashed lines.) The housing 2712 is immovably attached to the alignment plate 2402 by attachment screws 2704. Brake screws 2702 (visible only in Figure 27), however, determine whether the housing 2712 is movable with respect to the stiffener plate 182. While brake screws 2702 are loose, the housing 2712 is movable laterally (with respect to Figures 29 and 30) with respect to the stiffener plate 182. The differential screw 2708, including its stud extender 2806, of each AP assembly 2408 along with stud 2806 move 2952 with the housing 2712. Passages 2904 and 2906 in the stiffener plate 182 and wiring substrate 184, respectively, allow the stud extender 2804 to move with respect to the stiffener plate 182 and wiring board 184. While brake screws 2702 are tightened, however, the housing 2712 and thus the entire AP assembly 2408 is locked in place and cannot move with respect to the stiffener plate 182. The brake screws 2702 thus function like the locking nut 1804 of differential screw assemblies 1504 of probe assembly 1500 and allow for lateral movement like movement 1850 shown in Figure 18C.

As shown in Figure 28, two or more leverage tools 2860 (e.g., screw drivers) may be inserted through tool passages 2710 in the alignment plate 2402 and into openings 2802 in the stiffener plate 182. The leverage tools 2860 may then be used as levers to apply lateral (with respect to Figures 28 and 29) forces to the alignment plate 2402. Because the housings 2712 of the AP assemblies 2408 are firmly attached by attachment screws 2704 to the alignment plate 2402, those forces will move 2852 not only the alignment plate 2402 with respect to the stiffener plate 182, but will also move each of the housings 2712, which in turn moves 2854 the probe substrate 108 to which the studs 2806 of the AP assemblies 2408 are attached. Of course, the housings 2712 and probe substrate 108 move only if the brake screws 2702 of each housing 2712 are loose. If the brake screws 2702 are tightened, the housings 2712 do not move.

The alignment plates 2402 and AP assemblies 2408 are thus able to adjust the planarity and/or alignment of each probe substrate 108 in probe card assembly 2400 in six different degrees of movement and alter the shape of the probe substrate 108. That is, as shown in Figure 30, two leverage tools 2860 inserted in two pairs of tool passages 2710 through alignment plate 2402 and holes 2802 in the stiffener plate 182 (see Figure 28) can exert lateral forces 3004 in any direction in the "x, y" plane, and those forces 3004 cause the probe substrate 108 to be translated along the "x" and/or "y" axes and/or to be rotated (R_z) about the "z" axis. Moreover, because the nine AP assemblies 2408 are able to apply push and/or pull forces to a probe substrate 108, the nine AP assemblies 2408 are able to bring the same nine push or pull forces 2006 shown in Figure 20 to bear on a probe substrate 108. As shown in Figure 20, by selective application of those nine forces 2006, the probe substrate 108 can be translated along the "z" axis and rotated (R_x, R_y) about both the "x" and "y" axes. In addition to those six degrees of movement—translation along the "x,", "y," and "z" axes and rotation (R_x, R_y, R_z) about each of those axes—as shown in Figure 21, by applying alternating push and pull forces to the probe substrate 108, the shape of the probe substrate 108 can changed.

Figure 31 illustrates an exemplary process 3100 for making a probe card assembly (e.g., 100, 400, 1500, 2300, 2400) in which the probe array for contacting the device to be tested is made up of a plurality of probe sets (e.g., 112) each disposed on a separate probe substrate (e.g., 108).

At step 3102, a first probe substrate 108 comprising a first set of probes 112 is attached to a mounting assembly 104. For example, the lower right probe substrate 108 shown in Figure 3 may be attached to the mounting assembly 104. At step 3104, additional probe substrates 108 are attached to the mounting assembly 104. For example, the upper right, upper left, and lower left probe substrates 108 in Figure 3 may be attached to the mounting assembly 104. The probe substrates 108 attached to the mounting assembly 104 at steps 3102 and 3104 may be attached using any of the techniques and mechanisms discussed above so that each probe substrate 108 can be adjusted (e.g., planarized and aligned) as described herein. For example, each probe substrate 108 may be attached to the mounting assembly 104 using the spring assemblies 408 of probe card assembly 400, the leveling screw assemblies 1504 of probe card assembly 1500, or the AP assembles 2408 of probe card assembly 2400.

As noted in step 3104, as each probe substrate 108 is attached to the mounting assembly 104, the probe substrate 108 may be biased away from others of the probe substrates 108. For example, the first probe substrate 108 attached to the mounting assembly 104 at step 3102 may not be biased in any direction, and the probe substrates 108 subsequently attached to the mounting assembly at step 3104 may be biased away from the first. Alternatively, all of the probe substrates 108 attached at steps 3102 and 3104 may be biased away from each other. As yet another alternative, the probe substrates 108 need not be biased. If one or more of the probe substrates 108 is biased, spring assemblies 408 of probe card assembly 400, spring assembly 1508 of probe card assembly 1500, or spring 2214 of probe card assembly 2300 may be used to do so.

At step 3106, the alignment and/or planarity of one or more of the probe substrates 108 attached at steps 3102 and 3104 are adjusted to align and/or planarize the probe array (comprised of the probe sets 112 on each probe substrate 108). As described above, first adjustment mechanisms 106 and second adjustment mechanisms 110 of Figures 2A and 3 may be used to move one or more of the probe substrates 108 along the "x," "y," and/or "z" axes and/or rotate (R_x, R_y, R_z) the probe substrates 108 about the "x," "y," and/or "z" axes, as shown in Figure 2A and discussed above. For example, the differential screw assemblies 404 and cam assemblies 406 of probe card assembly 400 may be used to impart the forces and movements shown in Figure 14 to one or more of the probe substrates 108 attached to the mounting assembly 104 at steps 3102 and 3104. As another example, the leveling screw assemblies 1504 and set screws 1506 of probe card assembly 1500 may be used to impart the forces and movements shown in Figure 20 to one or more of the probe substrates 108. Leveling screw assemblies 1504 may also be used to alter a shape of one or more of the probe substrates 108 as shown in Figure 21. As yet another example, the alignment plate 2402 and AP assemblies 2408 of probe card assembly 2400 may be used to impart the forces and movements shown in Figures 20 and 30 to one or more of the probe substrates 108, and AP assemblies 2408 may also be used to alter a shape of one or more of the probe substrates 108 as shown in Figure 21.

The movement imparted to the probe substrates 108 during step 3106 may cause the spring contacts 808, 810 of an interposer 804 (see Figure 8) to scrub across contact terminals (not shown) on the mounting assembly 104 and/or the probe substrates 108. As is known, scrubbing a contact across a terminal improves the electrical connection between the contact and the terminal. This is because the scrubbing action may break through nonconductive (electrically) or highly electrically resistive contaminates (e.g., oxide) on the terminals.

At step 3108, the positions of the probe substrates (now aligned and/or planarized with the die terminals 22 as per step 3106) are locked into place. Although not shown, the first adjustment mechanism 106 and the second adjustment mechanism 110 may be configured to lock the probe substrates 108 into a selected position with respect to the mounting assembly 104. For example, the differential screw assemblies 404 of probe card assembly 400 may include a mechanism to lock screw 1102 so that it cannot rotate 1108. Screw 1202 of cam assemblies 406 may include a similar locking mechanism. Alternatively, the differential screw assemblies 404 and the cam assembly 406 may be configured such that screw 1102 and screw 1202 resist rotation unless a rotation tool (not shown) is applied to the screws 1102, 1202. In such a case, step 3108 is performed by implication once step 3106 is completed. The screws 1802 and 2204 of, respectively, leveling screw assemblies 1504 and lateral adjustment assemblies 2202, and differential screws 2708 of the AP assemblies 2408 may be similarly configured with a locking mechanism (not shown) or to resist rotation unless a rotation tool is applied. Regardless, locking nut 1804 of leveling screw assembly 1504, as described above, locks and stops the leveling screw assembly 1504 from moving laterally in passage 1702. Similarly, the locking screws 2702 of the AP assemblies 2408 of the probe card assembly 2400 stop the AP assemblies 2408 from moving laterally in passages 2904 and 2906 (see Figure 29). If such assemblies or assemblies are used to make lateral adjustment at step 3106, the locking nut 1804 and locking screws 2702 are locked down at step 3108.

As discussed above, the probe substrates 108 are adjusted at step 3106 relative to the mounting assembly 104. Because the mounting assembly 104 may be attached to a prober (e.g., like prober 2 of Figure 1) and a wafer 12 to be tested may be disposed in the prober 2, adjusting the probe substrates 108 (and the attached probes 112) with respect to the prober 2 adjusts the probe substrates (and the attached probes 112) with respect to the prober 2 and the die terminals 22 of the wafer 12. Once the probes 112 are planarized and/or aligned with respect to the die terminals 22 of the wafer 12 to be tested, the stage 6 can move the die terminals 22 into contact with the probes 112, and the dies of the wafer 12 can be tested.

Although specific embodiments and applications of the invention have been described in this specification, there is no intention that the invention be limited to these exemplary embodiments and applications or to the manner in which the exemplary embodiments and applications operate or are described herein. For example, the screw 1202 of the cam assemblies 406 may extend through the top of the mounting assembly 104 so that the cam assemblies 406 are adjustable from the top of the probe card assembly 400 rather than from the bottom as shown in Figure 12A. As yet another example, the various examples of the first adjustment mechanism 106 and the second adjustment mechanism 110 (see Figures 2A and 3) may be mixed and matched. As just one example, the cam assemblies 406 in probe assembly 400 may be replaced by the bracket 1510 and set screws 1506 of probe card assembly 1500. Similarly, the cam assemblies 406 may replace the bracket 1500 and set screws 1506 in probe card assembly 1500. As yet another example, some of the leveling screw assemblies 1504 in the probe card assembly 1500 may be replaced with the differential screw assemblies 404 of probe card assembly 400. Thus, forces 2006 illustrated in Figure 20 may be push only forces. As still another example of a modification to the embodiments described herein, the flexible wires 1704 of probe card assembly 1500 may be used in probe card assembly 400 in place of interposers 804. Similarly, the interposers 804 of probe card assembly 400 may be used in place of the wires 1704 in probe card assembly 1500. As yet another example, first adjustment mechanisms 106 and the second adjustment mechanism 110 may be driven by automatic actuating devices in response to control signals generated by a computer or other automatic control system. As still another example of variations to the exemplary embodiments described herein, although those embodiments are probe card assemblies, the alignment and planarization techniques described herein are generally applicable to use with any device comprising one or more substrates that must be planarized and/or aligned.

CLAIMS

1. A probe card assembly for contacting a device to be tested, said probe card assembly comprising:

a mounting structure;

a probe substrate comprising a set of probes disposed to contact said device to be tested; and

first moving means for moving said probe substrate substantially parallel with respect to said mounting structure.

2. The probe card assembly of claim 1 further comprising a plurality of probe substrates, each said probe substrate comprising an additional set of probes disposed to contact said device to be tested, wherein said first moving means is able to move more than one of said probe substrates substantially parallel with respect to said mounting structure.

3. The probe card assembly of claim 2 further comprising second moving means for moving at least two of said probe substrates substantially perpendicular with respect to said mounting structure.

4. The probe card assembly of claim 3, wherein said moving said probe substrate substantially perpendicular with respect to said mounting structure causes rotation of said probe substrate around an axis that is substantially parallel to said mounting structure.

5. The probe card assembly of claim 3, wherein said first moving means and said second moving means are capable of moving said at least two of said probe substrates in six degrees of motion.

6. The probe card assembly of claim 5, wherein said six degrees of motion comprise three degrees of translation and three degrees of rotation.

7. The probe card assembly of claim 3, wherein said second moving means is further capable of changing a shape of said at least two of said probe substrates.

8. The probe card assembly of claim 7, wherein said shape is a shape of a surface of each of said at least two probe substrates to which ones of said probe sets are attached.

9. The probe card assembly of claim 3, wherein said second moving means comprises a plurality of adjustable shafts extending from said mounting structure and adjusting said shafts moves said probe substrates.

10. The probe card assembly of claim 9, wherein said shafts are flexible in directions that are substantially parallel with said mounting structure.

11. The probe card assembly of claim 3, wherein

said mounting structure is configured to be attached to an apparatus for probing a semiconductor wafer, and

said first moving means and said second moving means are capable of moving said probe substrates to align said sets of probes to said semiconductor wafer.

12. The probe card assembly of claim 2 further comprising means for biasing ones of said probe substrates away from others of said probe substrates.

13. The probe card assembly of claim 2, wherein said first moving means comprises an adjustable shaft extending from said mounting substrate and adjusting said shaft effects separation of adjacent probe substrates.

14. The probe card assembly of claim 1, wherein said first moving means comprises a movable cam and moving said cam moves said probe substrate.

15. The probe card assembly of claim 1, wherein said first moving means comprises an adjustable set screw, and adjusting said set screw moves said probe substrate.

16. The probe card assembly of claim 1, wherein said moving said probe substrate substantially parallel with respect to said mounting structure causes rotation of said probe substrate around an axis that is substantially perpendicular to said mounting structure.

17. A method of making a probe card assembly, said method comprising:

attaching a plurality of probe substrates to a mounting structure, each said probe substrate comprising a set of probes disposed to contact a device to be tested; and after attaching said probe substrates to said mounting structure, moving at least one of said probe substrates substantially in parallel with respect to said mounting structure.

18. The method of claim 17 further comprising moving at least one of said probe substrates substantially perpendicular with respect to said mounting structure.

19. The method of claim 18, wherein said second moving step causes rotation of said at least one of said probe substrates about an axis that is substantially parallel to said mounting structure.

20. The method of claim 19 further comprising attaching said mounting structure to an apparatus for probing a semiconductor wafer, and wherein said first moving step and said second moving step align said sets of probes with said semiconductor wafer.

21. The method of claim 17 further comprising changing a shape of at least two of said probe substrates.

22. The method of claim 21, wherein said shape is a shape of a surface to which a set of said probes is attached.

23. The method of claim 17, wherein said attaching step comprises biasing ones of said probe substrates away from others of said probe substrates.

24. The method of claim 17, wherein said first moving step comprises adjusting a shaft extending from said mounting substrate to effect separation of adjacent probe substrates.

25. The method of claim 17, wherein said first moving step comprises moving a cam that affects movement of one of said probe substrates.

26. The method of claim 17, wherein said first moving step comprises adjusting a set screw that affects movement of said probe substrates.

27. The method of claim 17, wherein said second moving step comprises moving a plurality of adjustable shafts extending from said mounting structure that affect movement of said probe substrates.

28. The method of claim 27, wherein said shafts are flexible in directions that are substantially parallel with said mounting structure.

29. The method of claim 17, wherein said first moving step causes rotation of said at least one of said probe substrates about an axis that is substantially perpendicular to said mounting structure.

30. A probe card assembly comprising:

a mounting structure;

a plurality of probe substrates each comprising a set of probes disposed to contact a device to be tested; and

moving means for moving more than one of said probe substrates with respect to said mounting structure, wherein said moving comprises a directional component that is perpendicular to said mounting structure and a directional component that is parallel to said mounting structure.

31. The probe card assembly of claim 30, wherein said moving means comprises a plurality of moveable assemblies configured to selectively move at least a part of said more than one of said probe substrates toward or away from said mounting structure.

32. The probe card assembly of claim 31, wherein said moveable assemblies are attached to said more than one of said probe substrates and are further moveable in parallel with said mounting structure.

33. The probe card assembly of claim 32, wherein said moveable assemblies comprise a locking mechanism that, when activated, prevents said parallel movement of said moveable assemblies.

34. The probe card assembly of claim 33, wherein said moveable assemblies comprise a split nut, differential screw assembly.

Figure 1

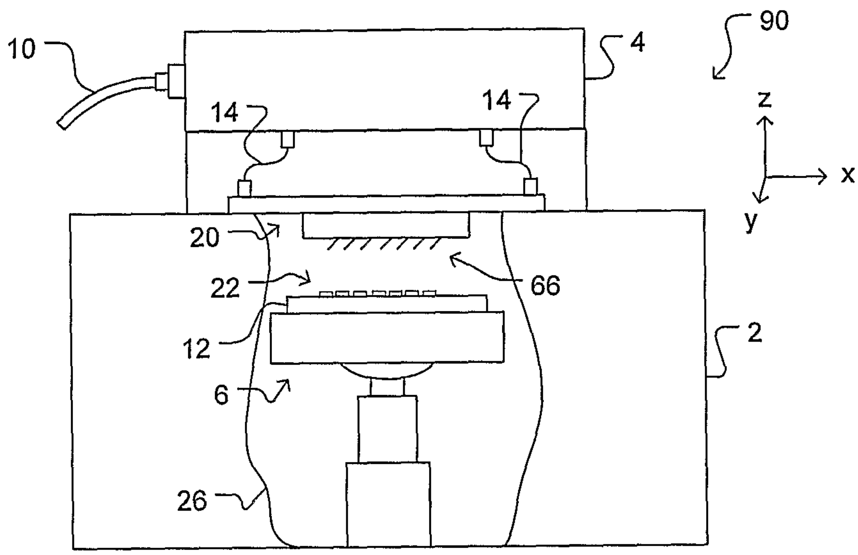


Figure 2A

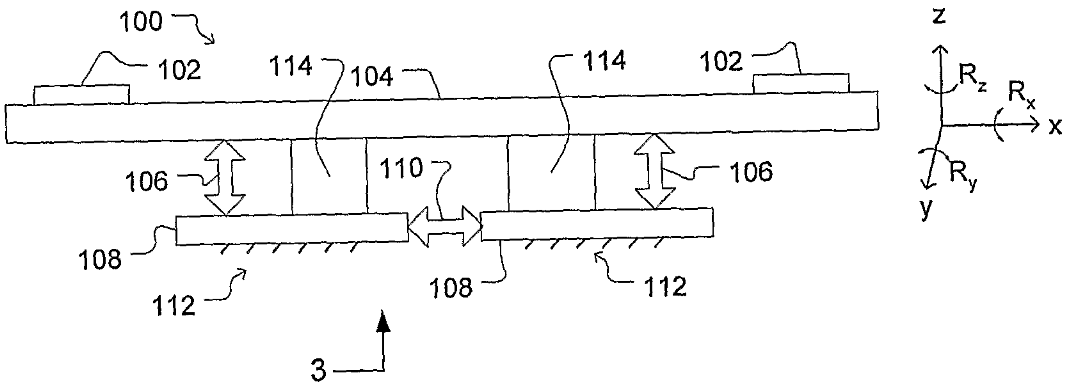


Figure 2B

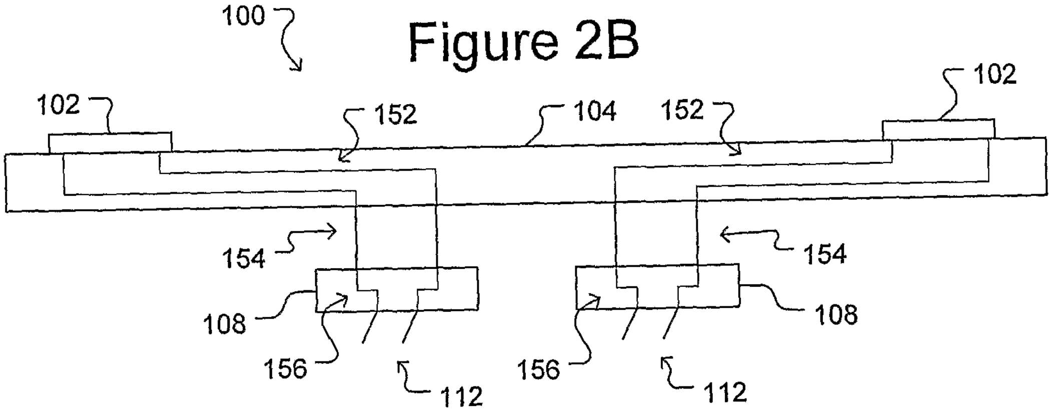


Figure 2C

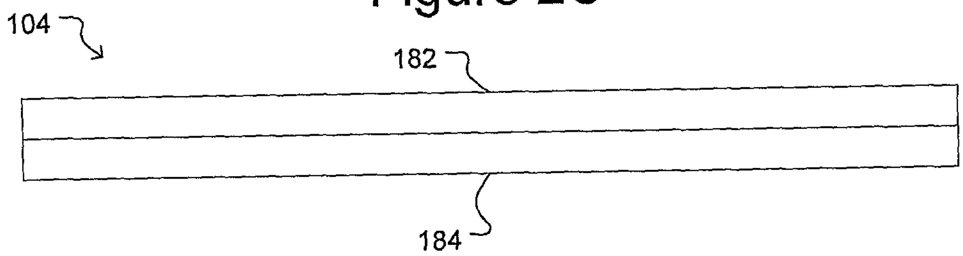
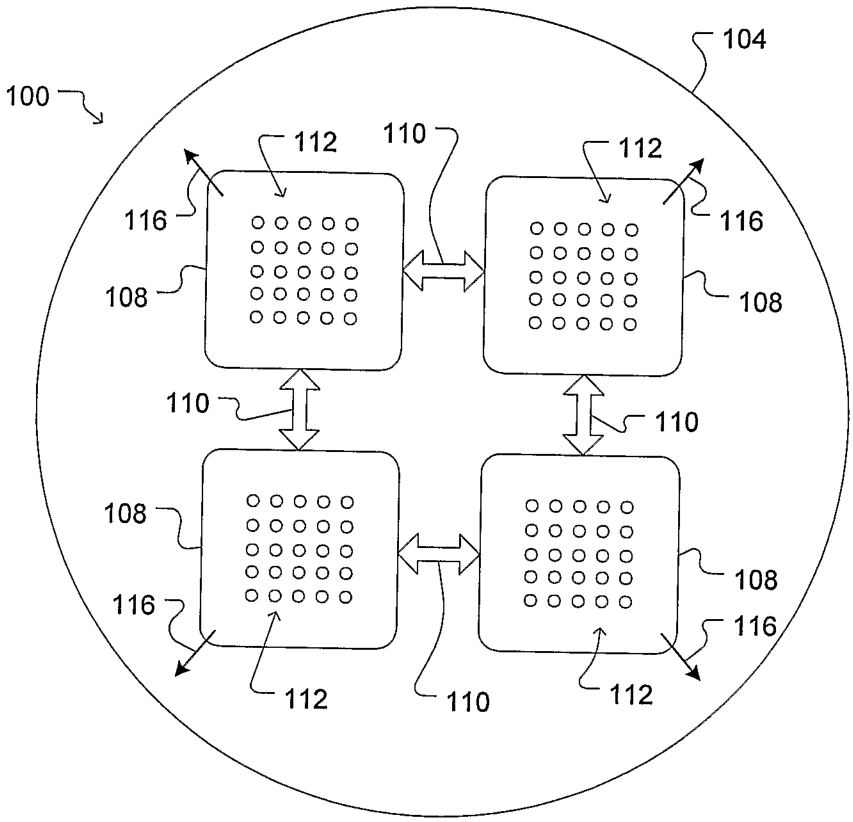


Figure 3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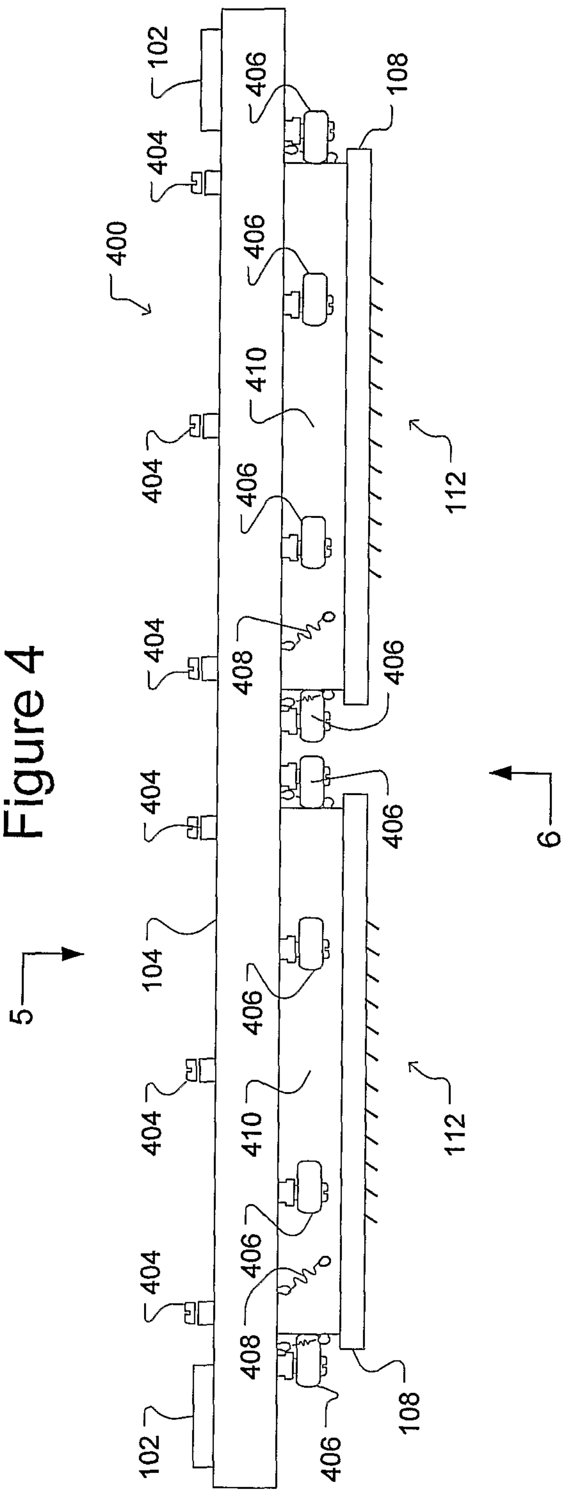

Figure 4

Figure 5

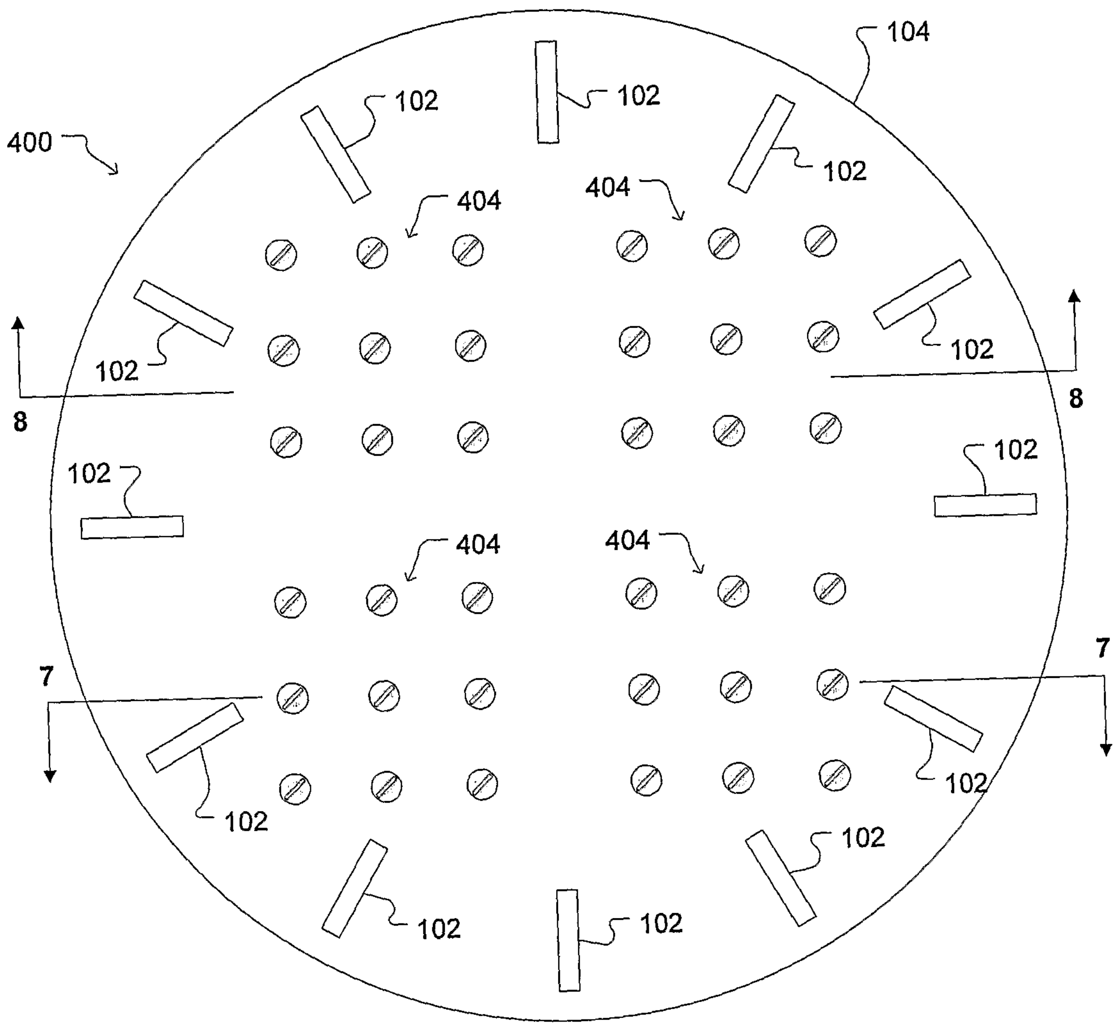
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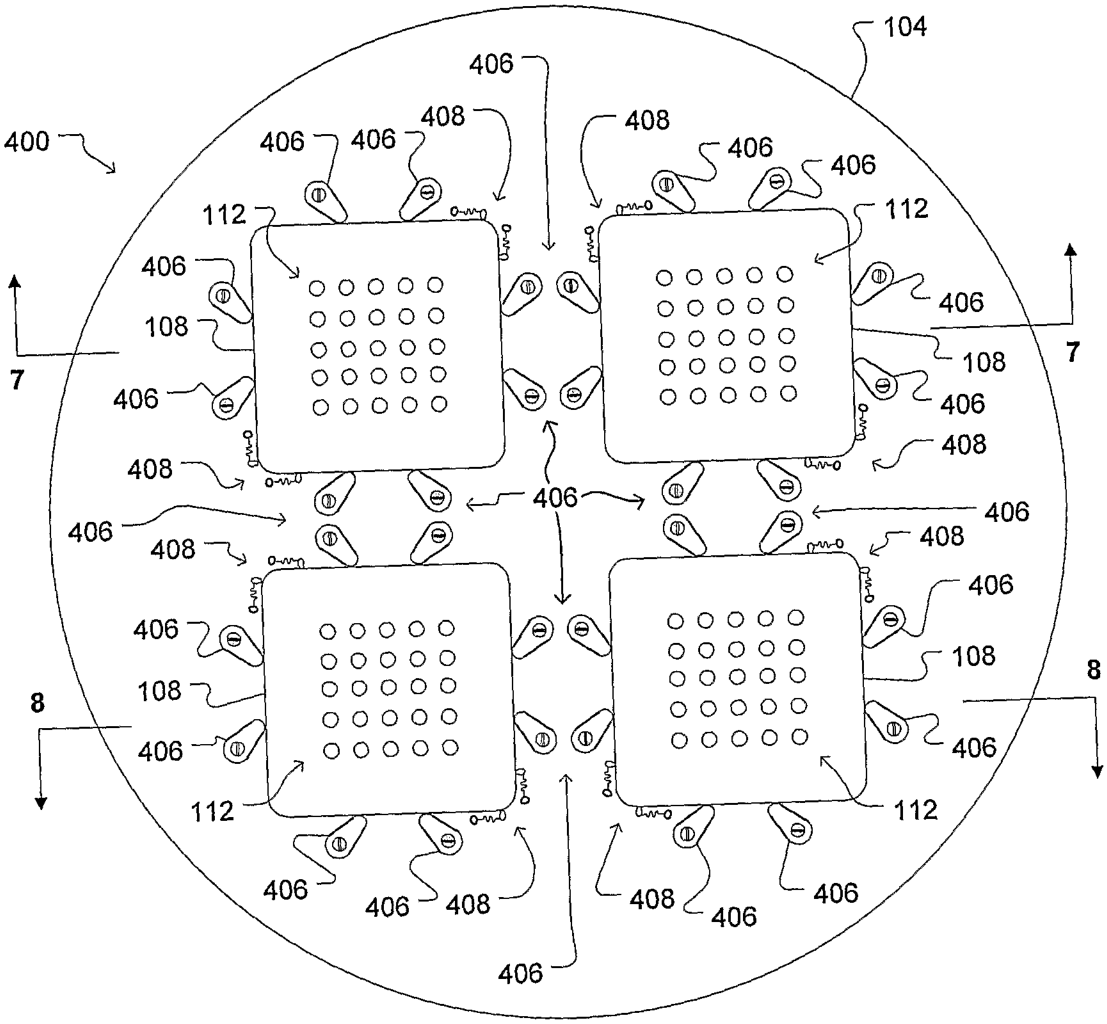
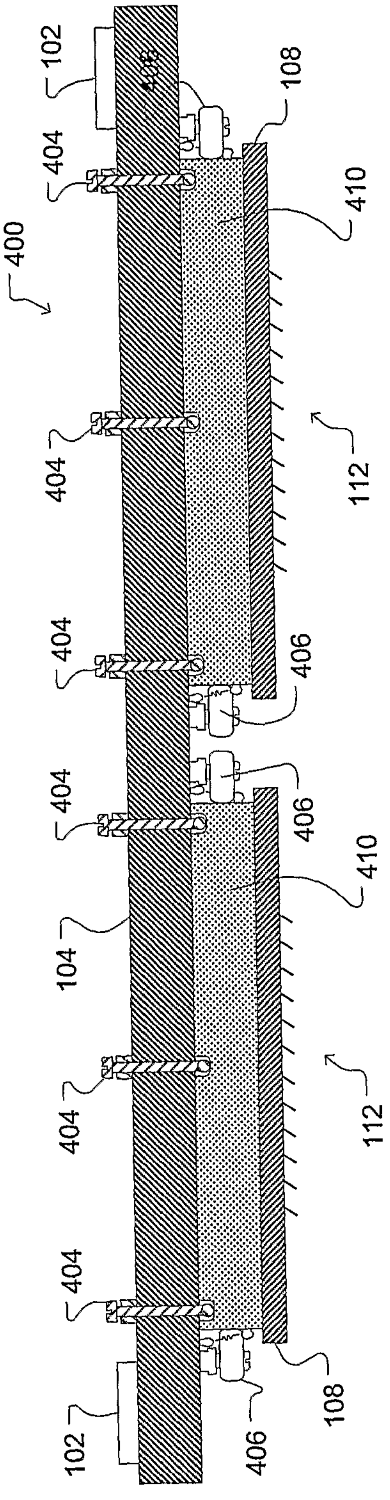
Figure 6

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102

Figure 7

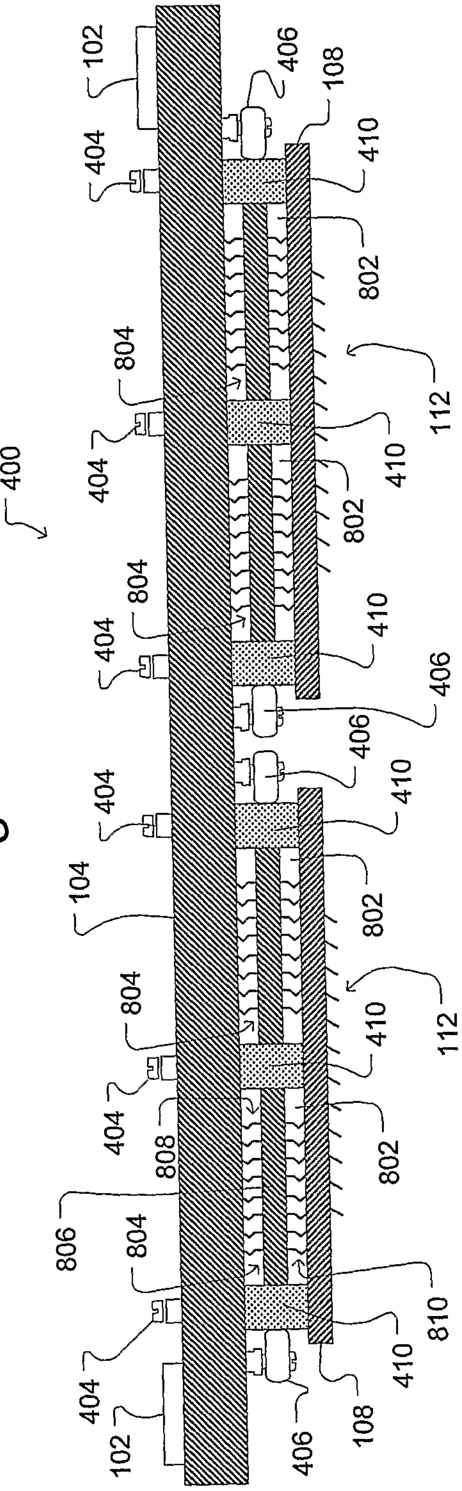


Figure 8

Figure 9

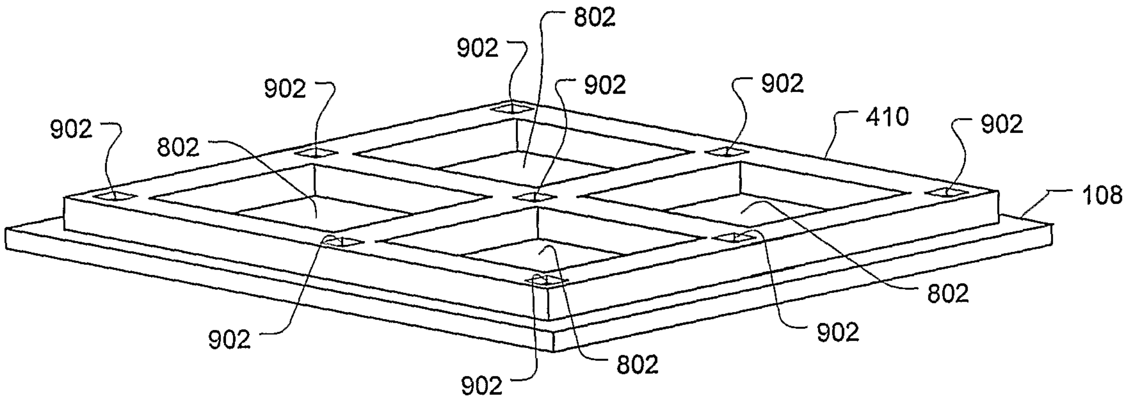


Figure 11A

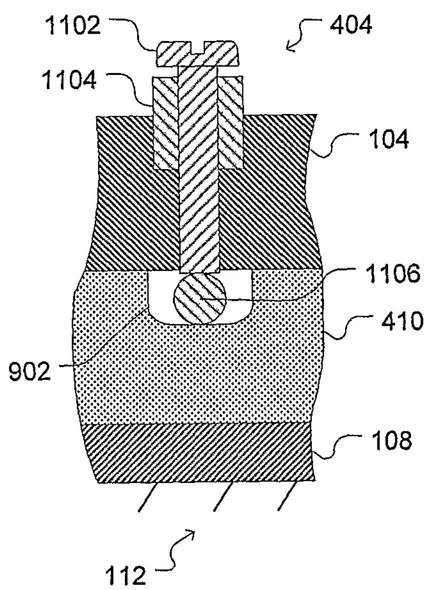


Figure 11B

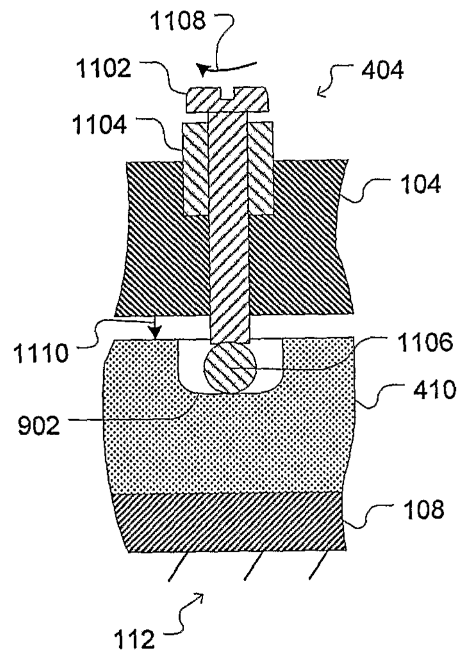


Figure 10A

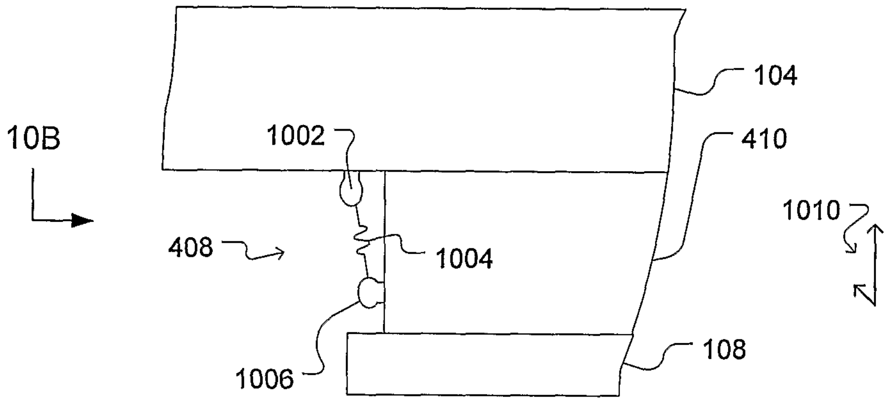


Figure 10B

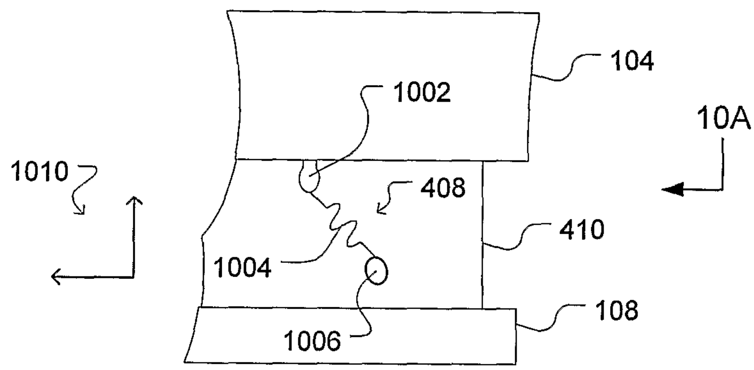


Figure 12A

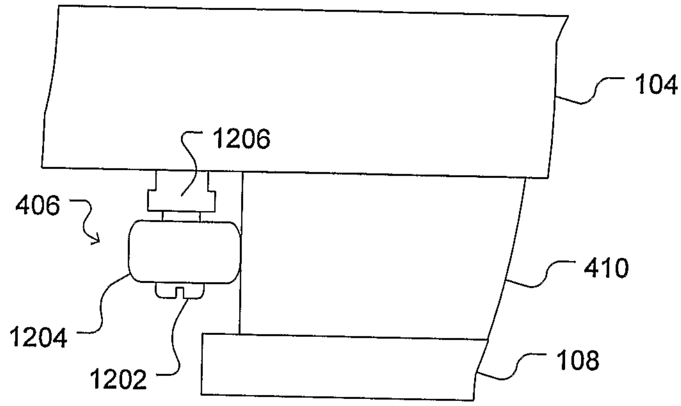


Figure 12B

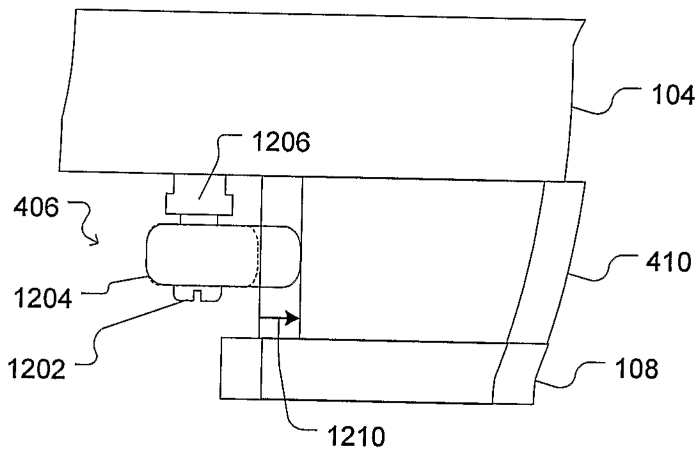


Figure 13A

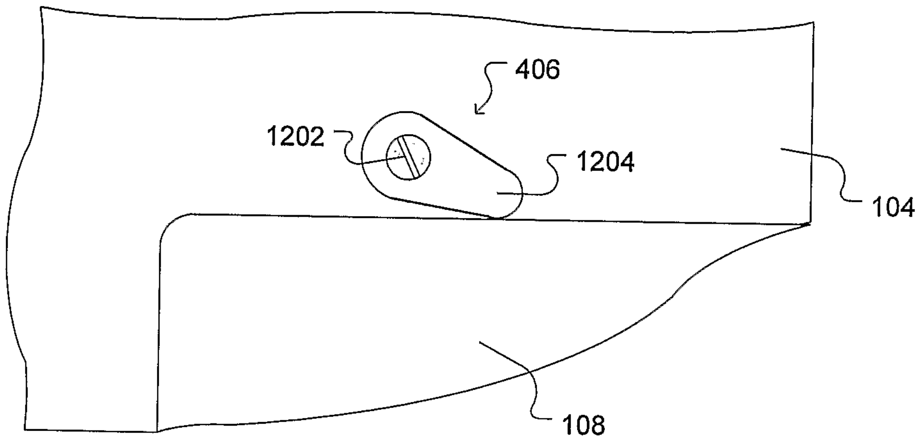
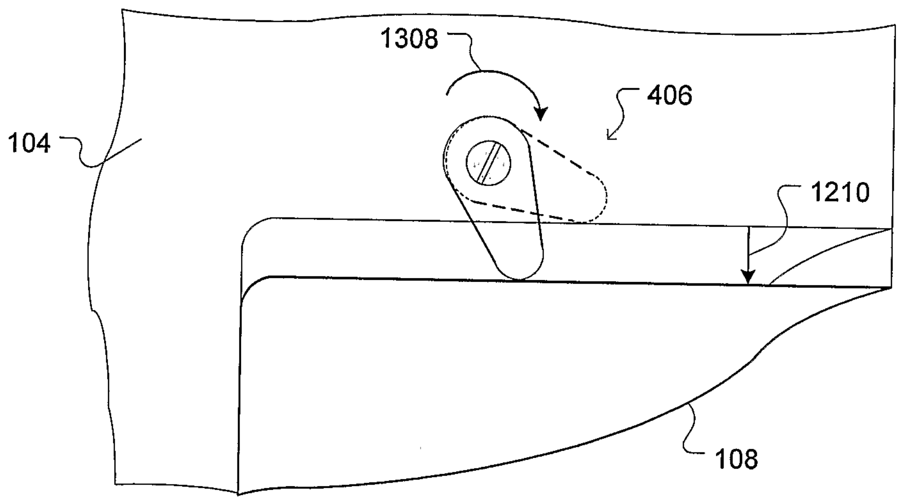


Figure 13B



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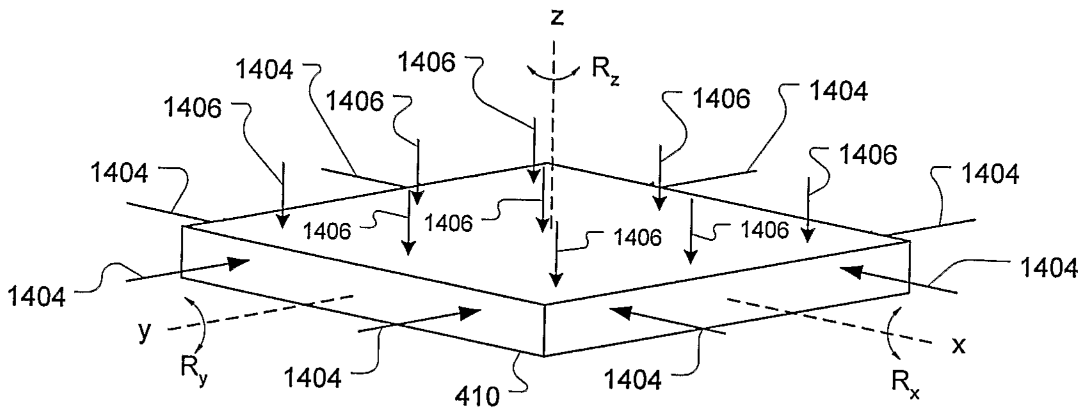
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Figure 15

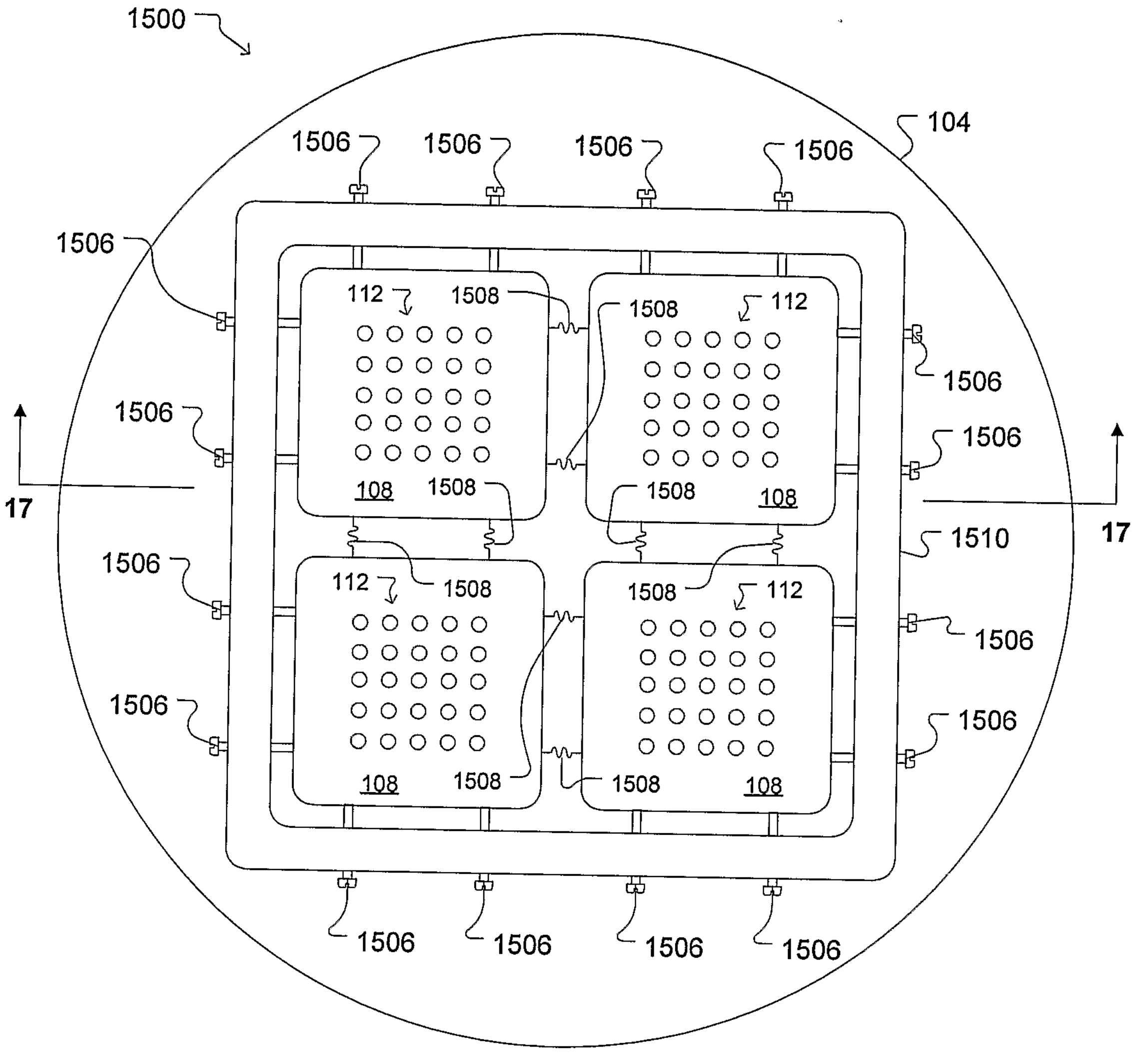
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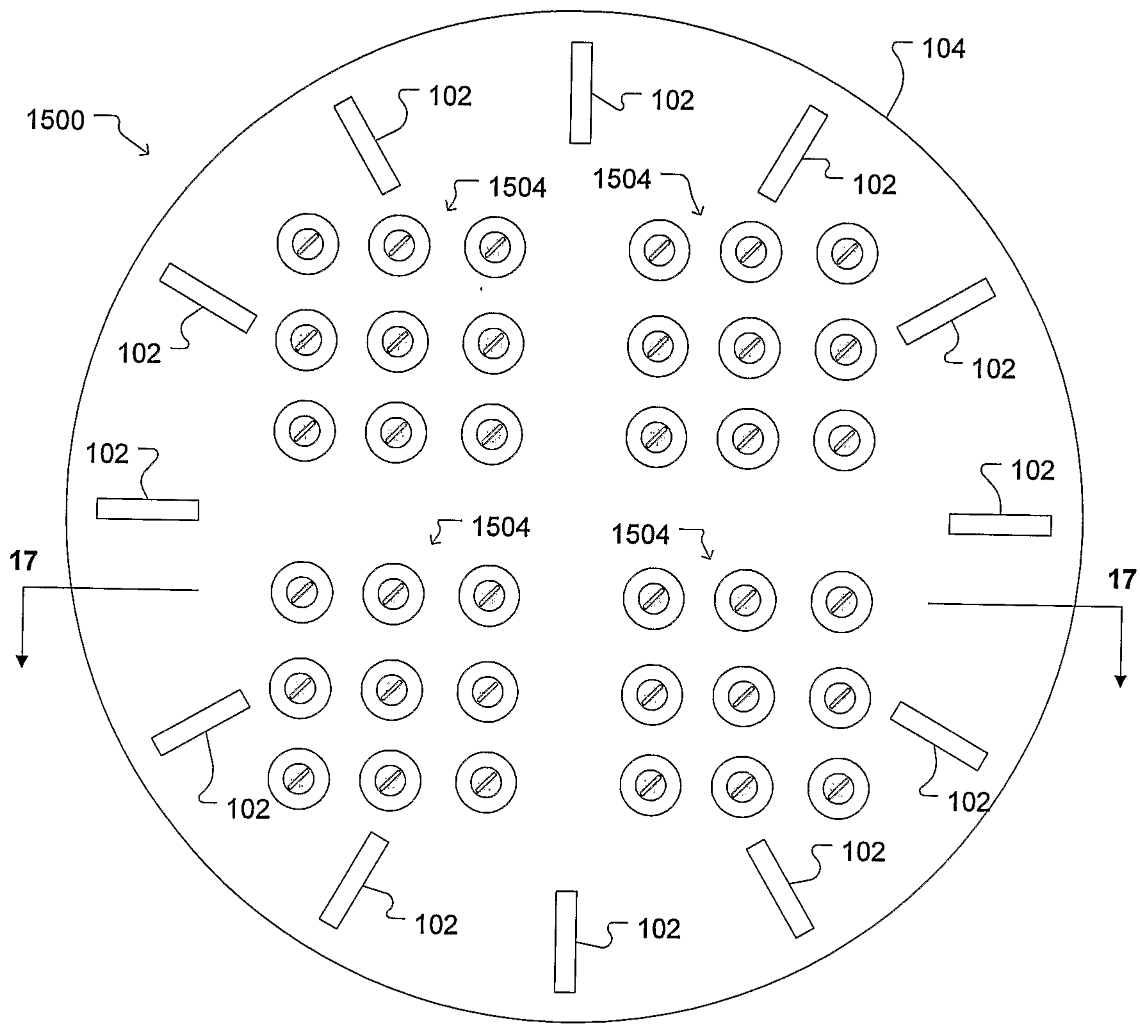
Figure 16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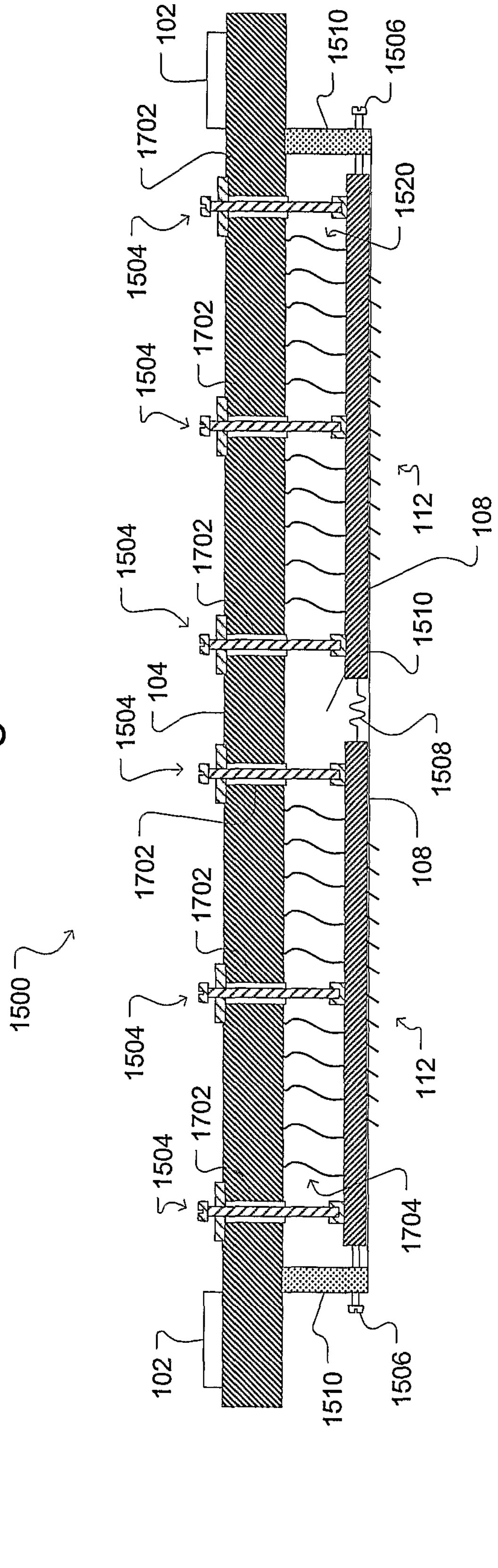


Figure 17

Figure 18A

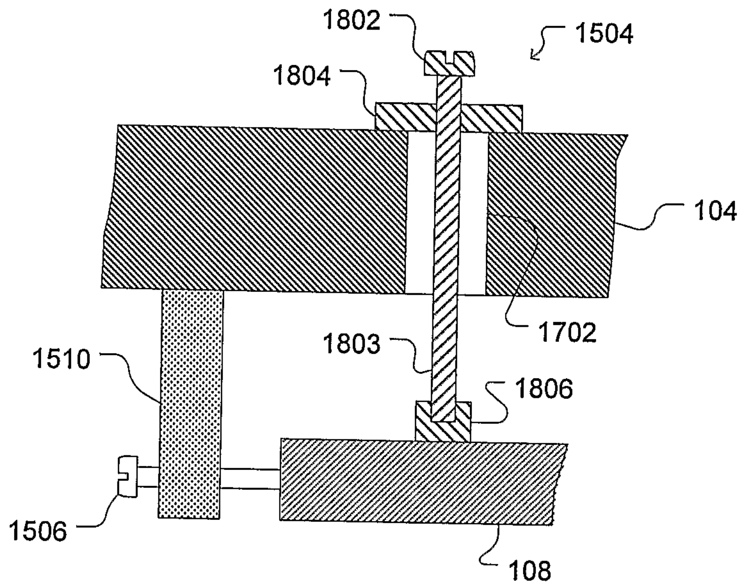


Figure 18B

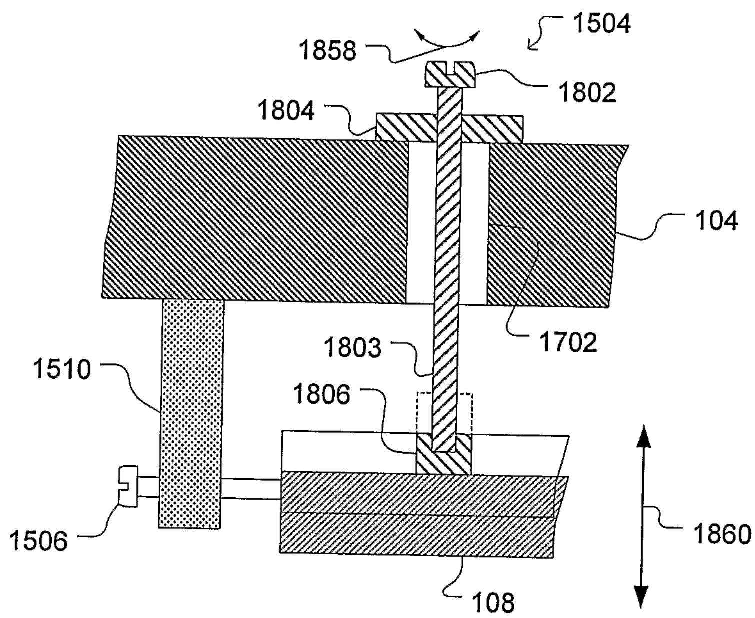


Figure 18C

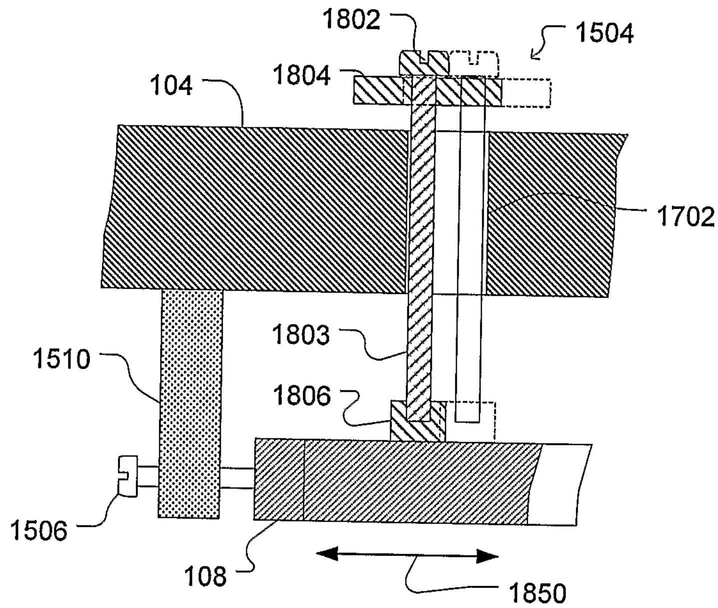


Figure 18D

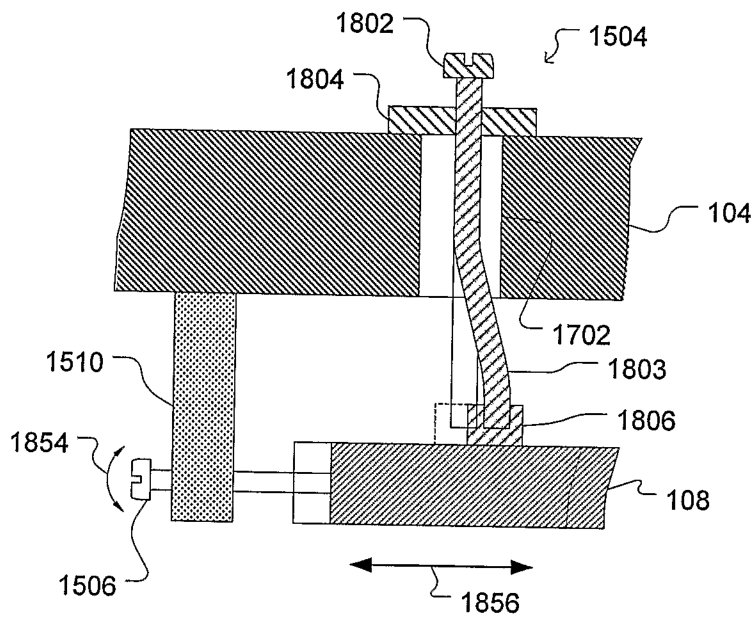


Figure 19

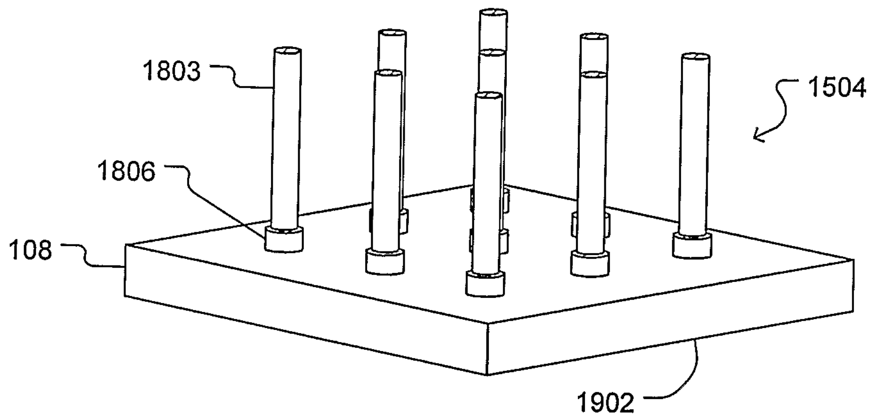


Figure 20

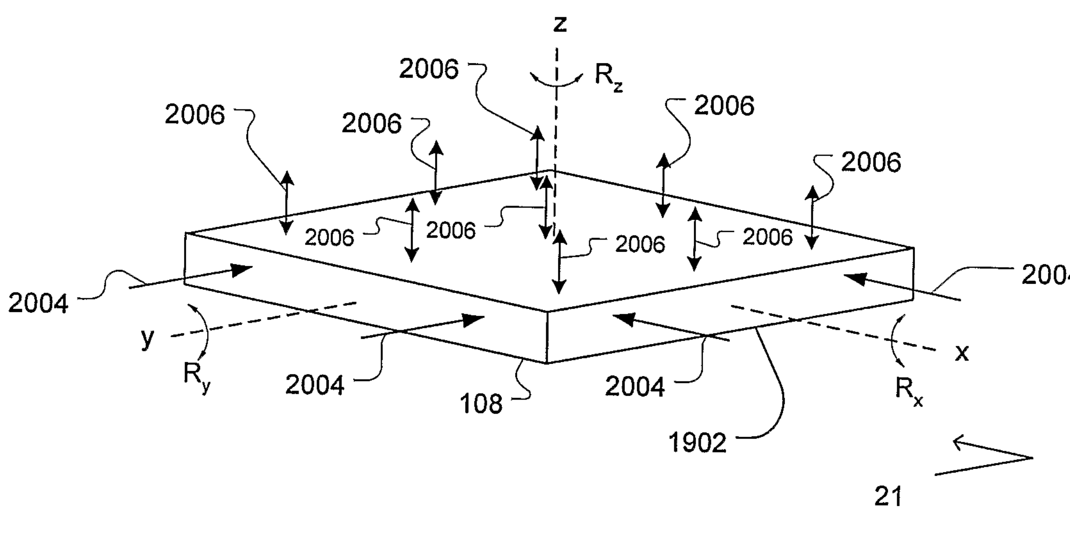


Figure 21

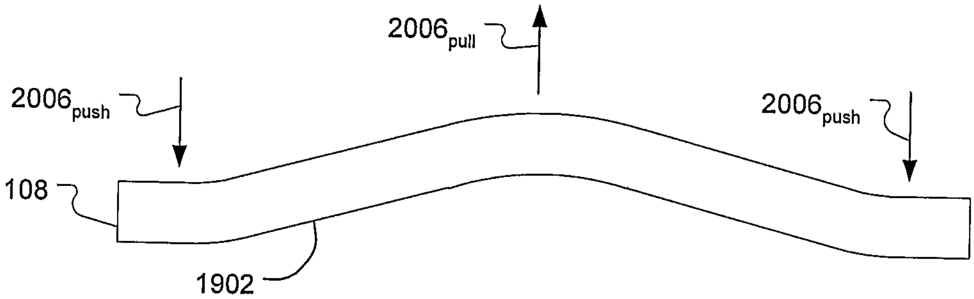


Figure 22A

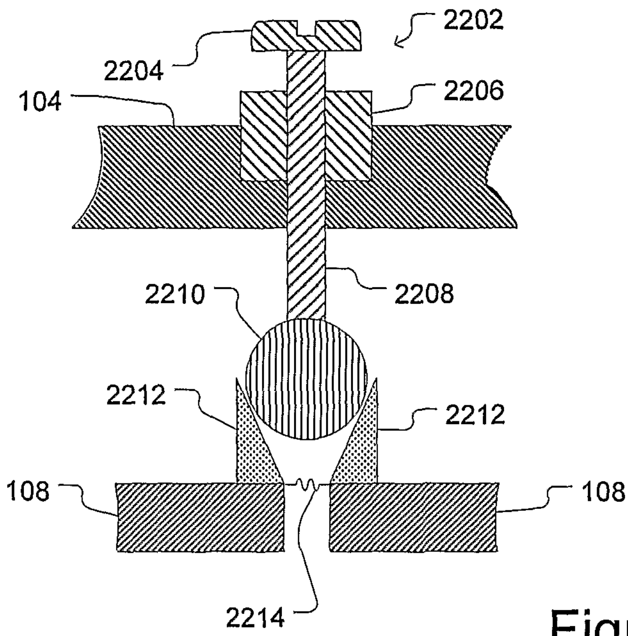


Figure 22B

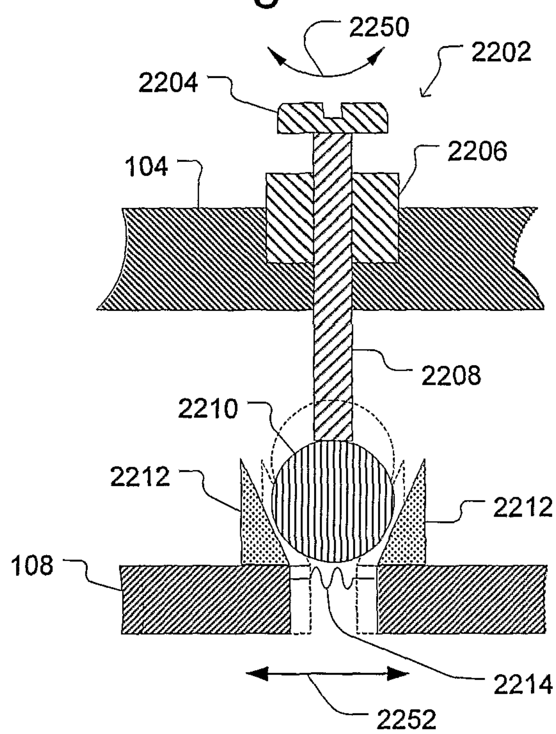
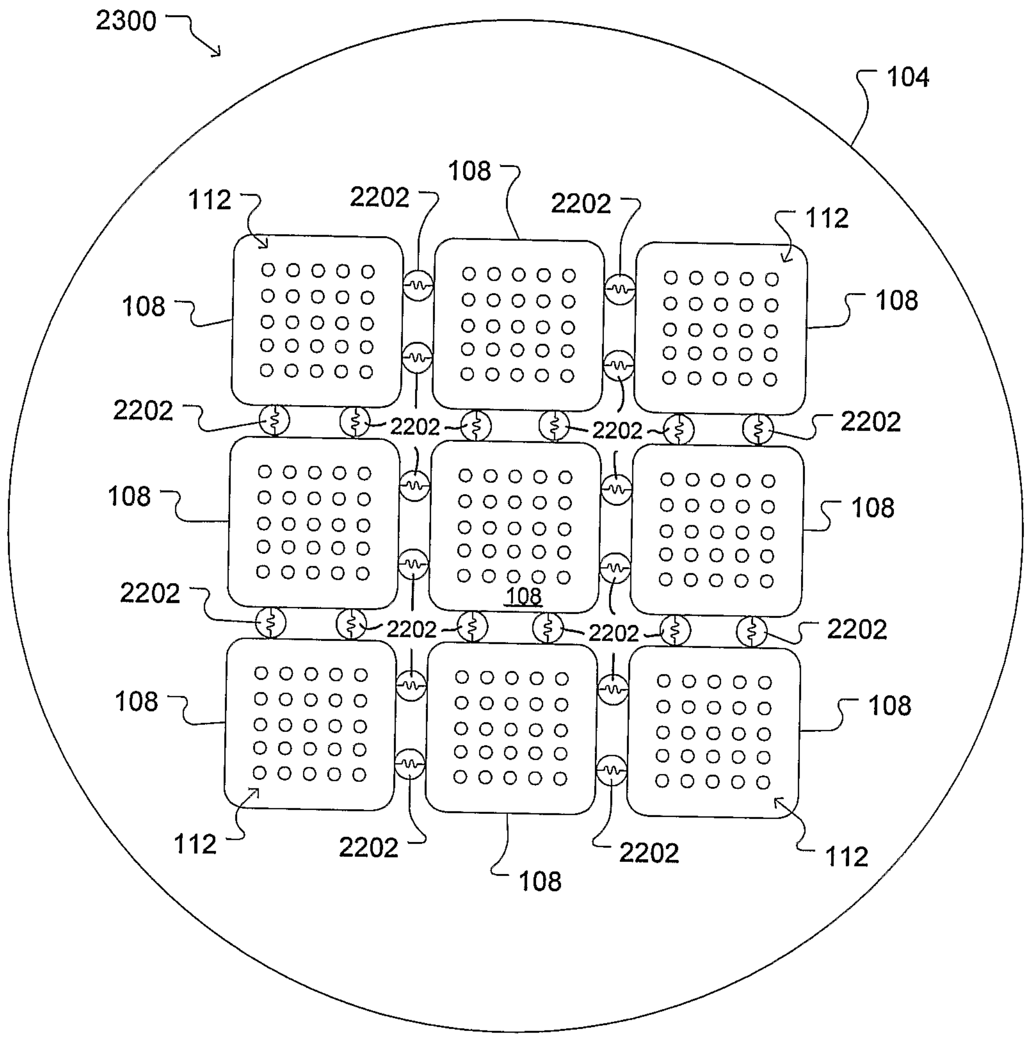


Figure 23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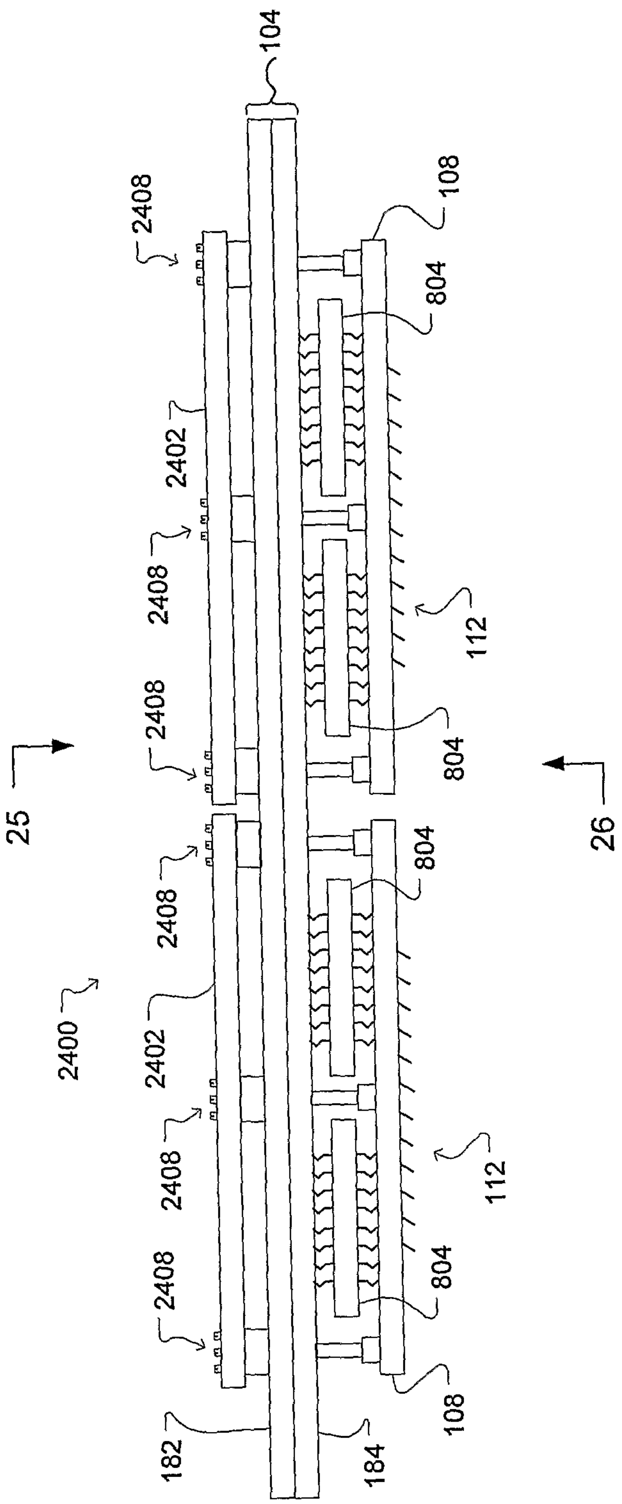
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Figure 24

Figure 25

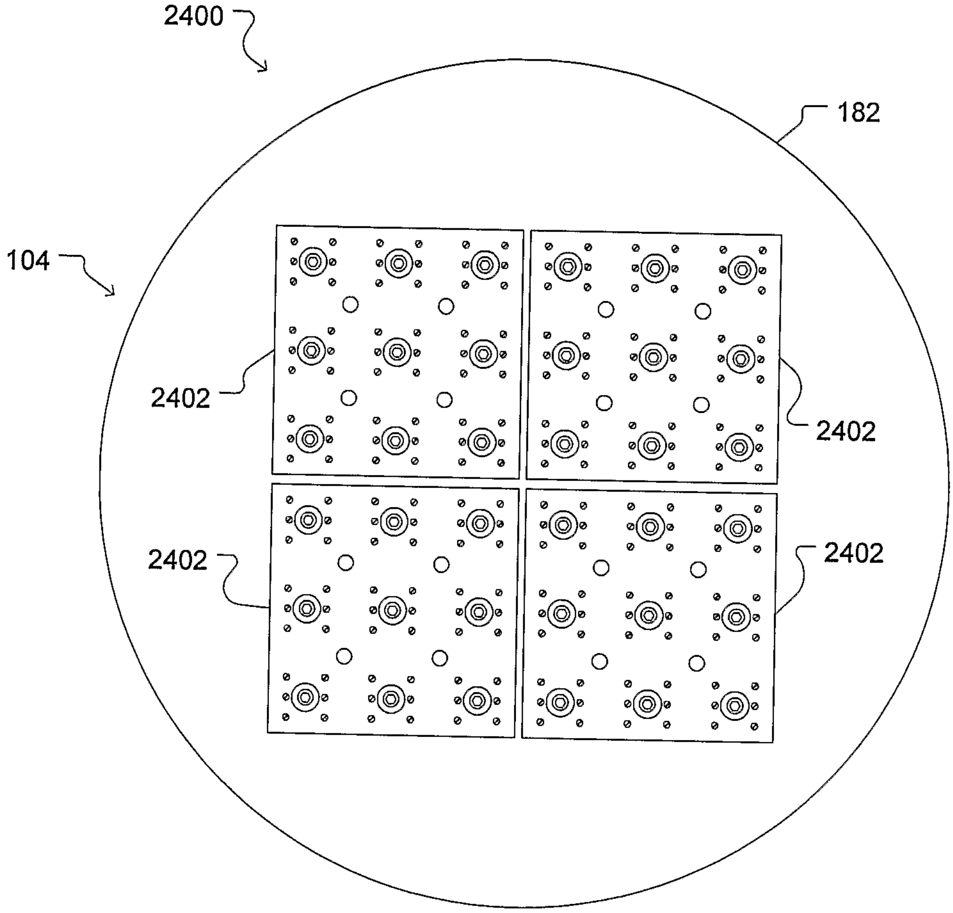


Figure 26

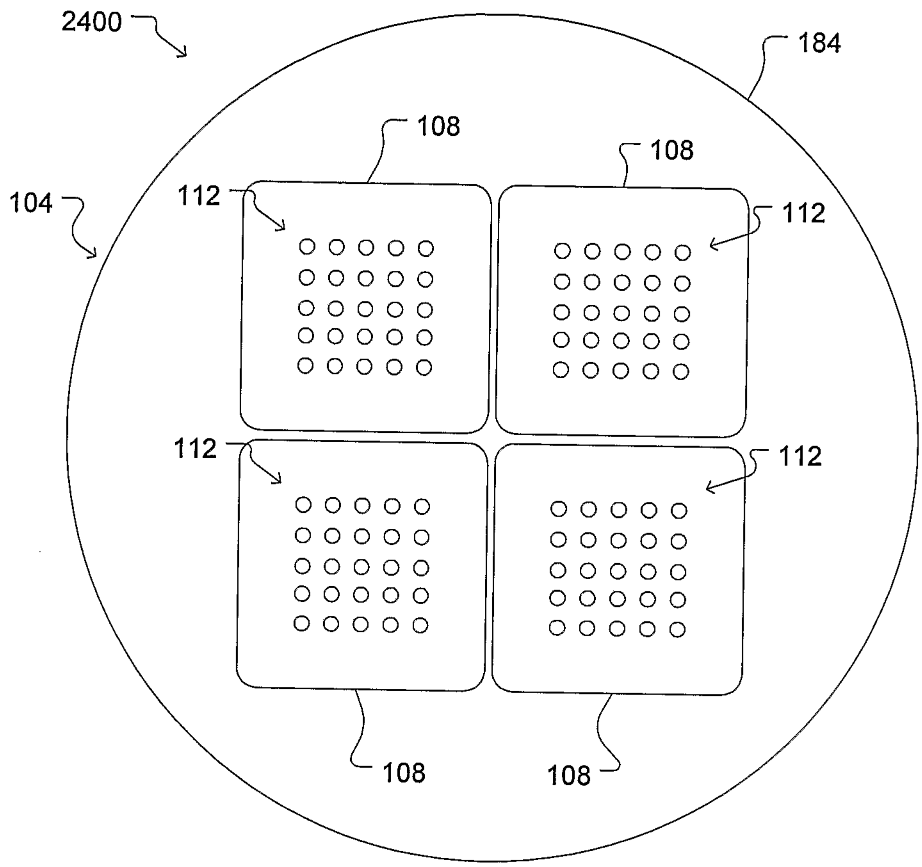
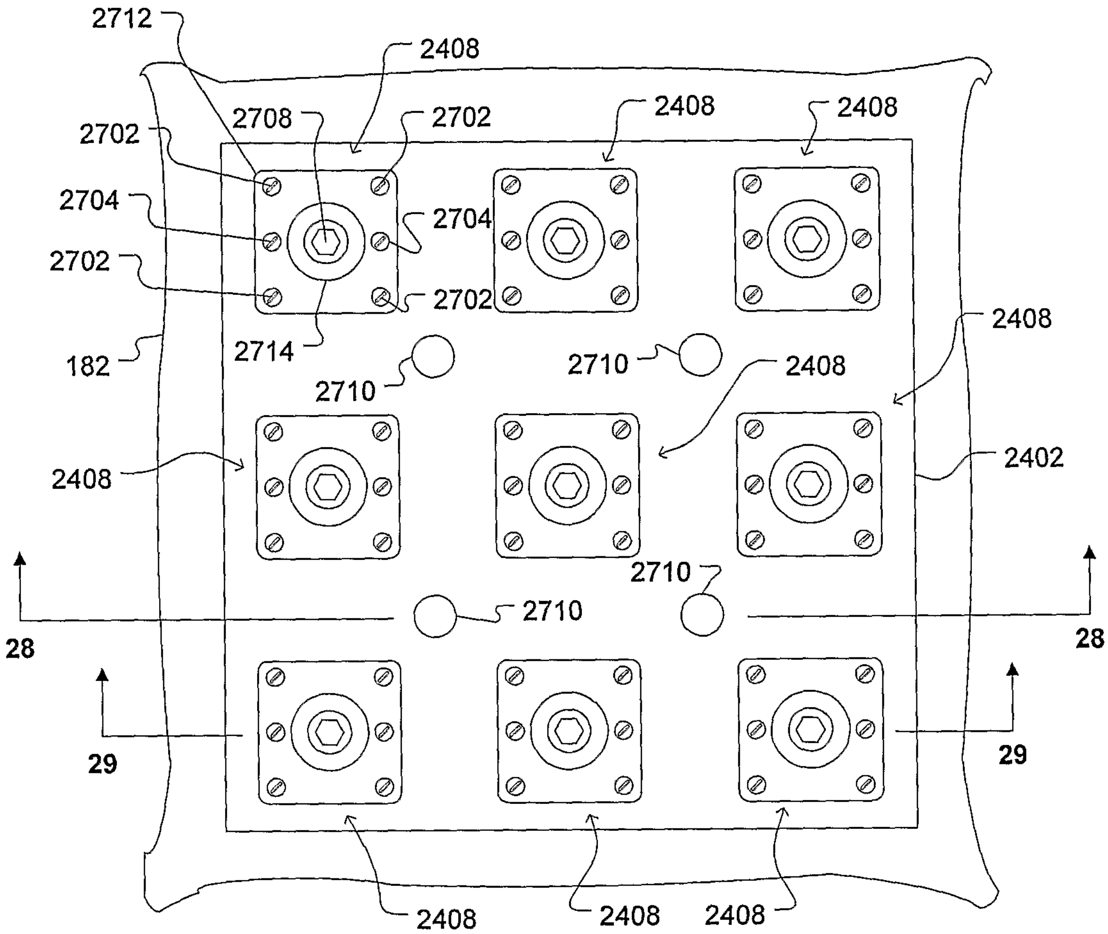


Figure 27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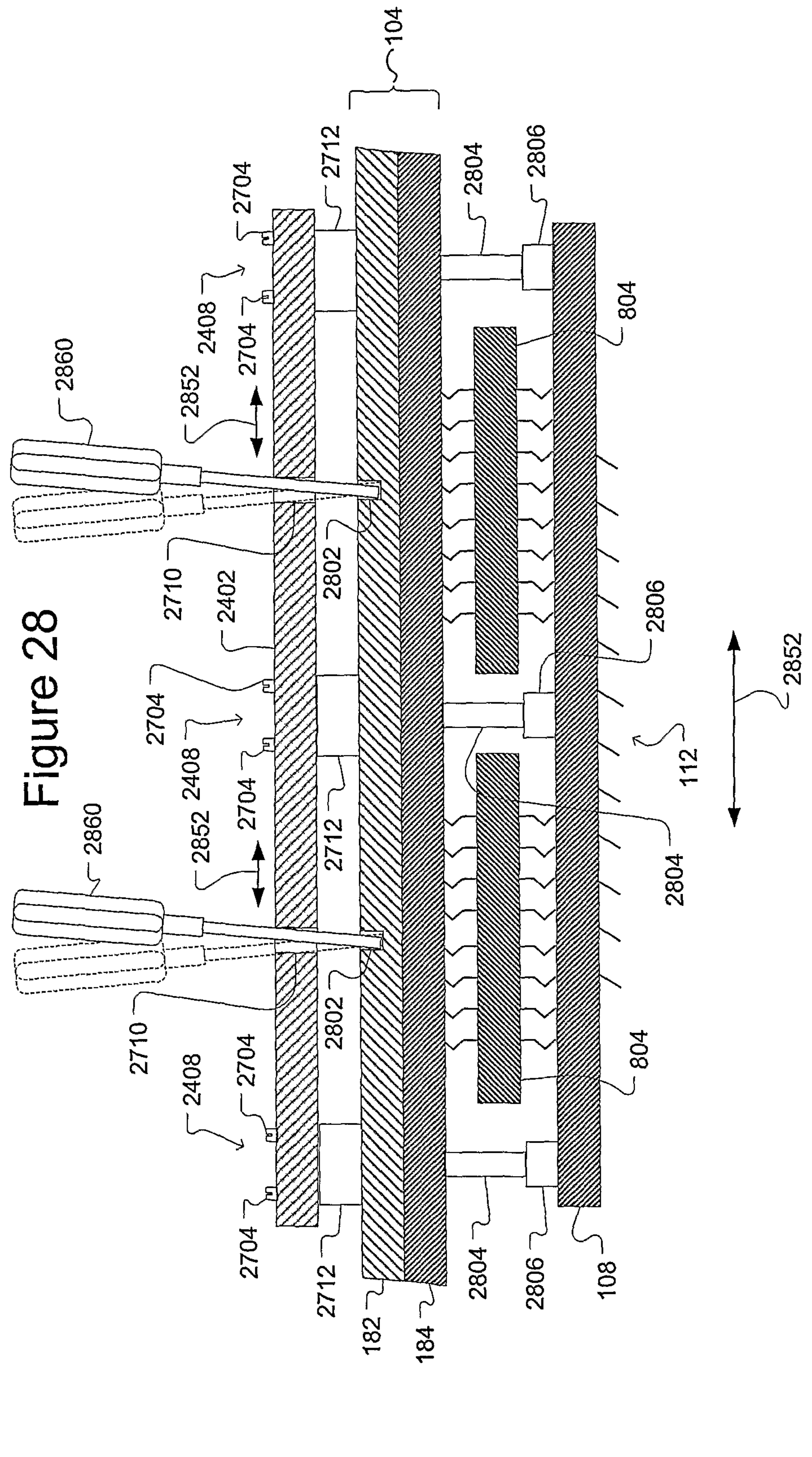
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Figure 28

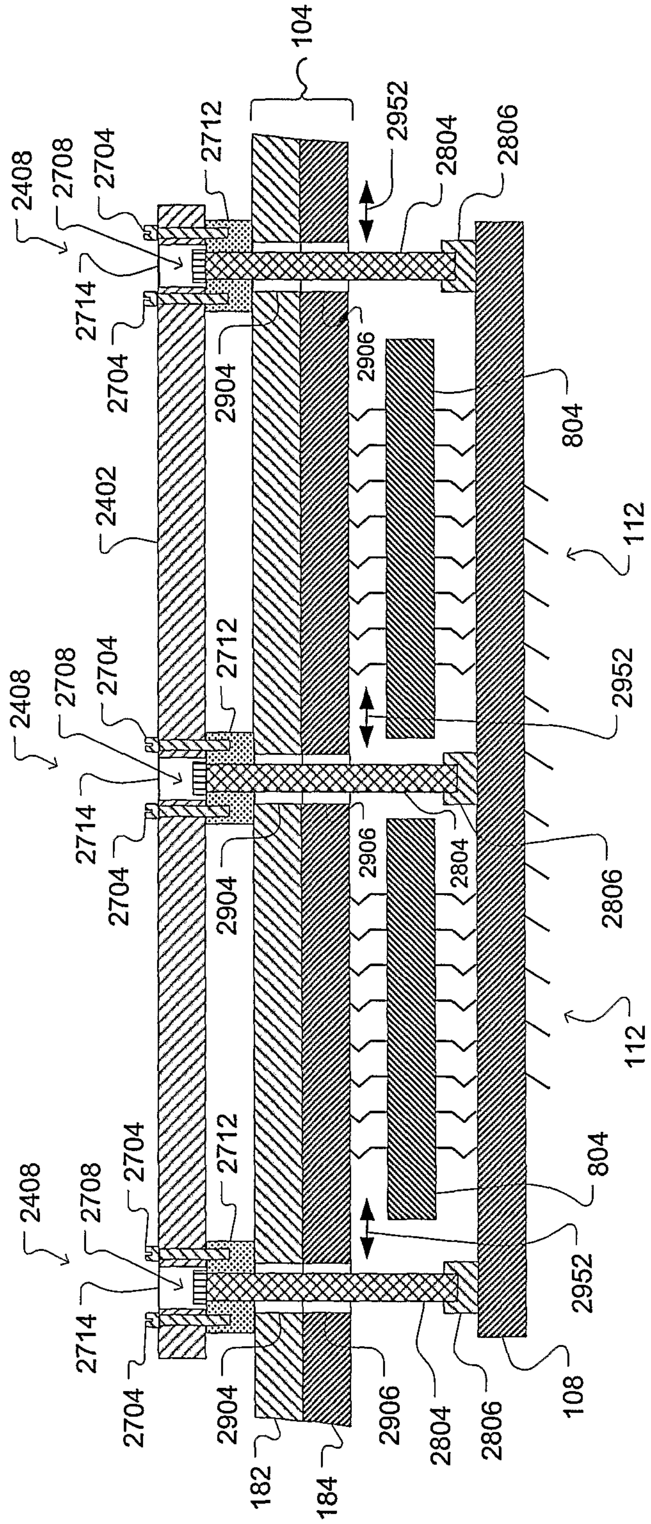
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Figure 29

Figure 30

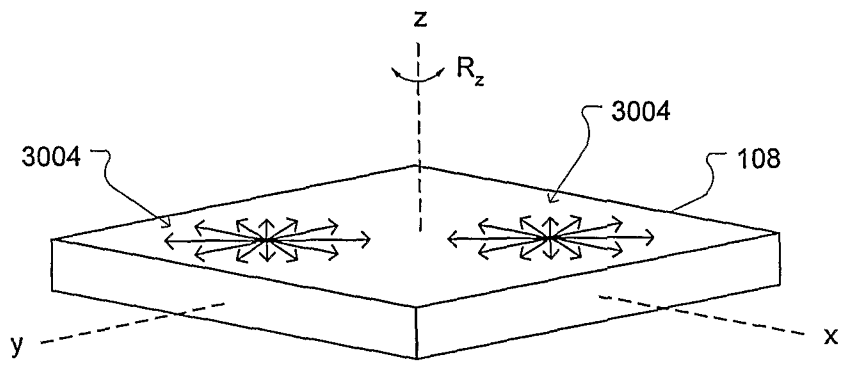

Figure 31