Embodiments of the present invention generally relate to an apparatus for processing a substrate and more specifically to a device that will transfer electrical power and/or control signals between a stationary base and a rotating platen without involving mechanical contact. The device does not suffer the drawbacks of conventional slip rings burdened with moving surfaces. In one embodiment, an apparatus for processing a substrate is provided. The apparatus includes a platen assembly having a surface for supporting a planarizing material and disposed on a stationary base so that the platen assembly may rotate relative to the base. The apparatus further includes a coupling assembly for transferring electrical energy from a primary coil to a secondary coil. The coupling assembly includes the primary coil of wire wrapped around a first core; the first core coupled to the base; the secondary coil of wire wrapped around a second core; and the second core coupled to the platen assembly.
PLATEN ASSEMBLY UTILIZING MAGNETIC SLIP RING

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Embodiments of the present invention generally relate to an apparatus for processing a substrate and more specifically to a device that will transfer electrical power and/or control signals between a stationary base and a rotating platen without involving mechanical contact.

[0004] 2. Description of the Related Art

[0005] Semiconductor wafer processing systems generally include a polishing head, a platen and polishing material disposed on the platen. A substrate retained in the polishing head is pressed against the polishing material and moved relative to the polishing material in the presence of a polishing fluid.

[0006] In chemical mechanical planarizing (CMP) systems, abrasives, typically contained in the polishing fluid or polishing material, remove material from the surface of the substrate synergistically with the chemical activity provided by the polishing fluid. One type of polishing material that includes abrasives disposed therein is known as abrasive sheet material. The abrasive sheet material comprises a plurality of abrasive particles suspended in a resin binder that is disposed in discrete elements on a backing sheet. Generally, a web of abrasive sheet material is periodically advanced over the course of polishing a number of substrates as the polishing surface of the web is consumed by the polishing process. A vacuum is typically applied between the web and platen to fix the web to the platen during the polishing process wherein the platen and web are related. When the web is advanced, the vacuum is removed, freeing the web from the platen's surface.

[0007] Electrochemical mechanical planarizing (ECMP) is a technique used to remove conductive materials from a substrate surface by electrochemical dissolution while concurrently polishing the substrate with reduced mechanical abrasion compared to conventional planarizing processes. ECMP systems may generally be adapted for deposition of conductive material on the substrate by reversing the polarity of the bias. Electrochemical dissolution is performed by applying a bias between a cathode and a substrate surface to remove conductive materials from the substrate surface into a surrounding electrolyte. Typically, the bias is applied to the substrate surface by a conductive polishing material on which the substrate is processed. A mechanical component of the polishing process is performed by providing relative motion between the substrate and the conductive polishing material that enhances the removal of the conductive material from the substrate.

[0008] In either CMP or ECMP systems, slip rings are provided to transfer electrical power and control signals between a stationary base to a rotating platen. Slip rings consist of one or more rings made of conductive material, such as a copper alloy, and brushes also made of conductive materials. Either the rings or the brushes can be interconnected to the stationary base, and the counterpart to the rotating platen. An electrical current is fed to the ring or brush on the stationary side and the current passes through between the ring and the brushes by means of mechanical contact therebetween. Since mechanical contact of moving surfaces is involved, a small dust particle or mechanical imperfection of the related material forming the ring or brush can cause the two surfaces to break contact momentarily. This break of contact is reflected as a break in current, which may cause noise pulses or noise levels. This problem is exasperated by the polishing debris generated in CMP and ECMP systems.

[0009] To somewhat overcome this noise problem, many slip rings employ multiple brushes/rings. The rationale behind such a design is that if there are many brushes-ring contacts per circuit, when one or more brushes/rings break contact, others will remain in contact to properly pass the current. However, when any one brush/ring becomes dirty, the probability of all brushes/rings losing contact is greatly increased, which may result in high noise levels, or in some cases, a momentary loss of the signal being transferred between the ring and the brush and, thus, between the rotating and stationary equipment.

[0010] Therefore, there is a need for a device that will transfer electrical power and/or control signals between a stationary base and a rotating platen without involving mechanical contact.

SUMMARY OF THE INVENTION

[0011] Embodiments of the present invention generally relate to an apparatus for processing a substrate and more specifically to a device that will transfer electrical power and/or control signals between a stationary base and a rotating platen without involving mechanical contact. The device does not suffer the drawbacks of conventional slip rings burdened with moving surfaces. Conventional slip rings are subjected to debris and arcing conditions which might cause relatively high noise levels to be encountered or even momentary loss of the electrical signals that are being transferred between the stationary and rotating equipment.

[0012] In one embodiment, an apparatus for processing a substrate is provided. The apparatus includes a platen assembly having a surface for supporting a planarizing material and disposed on a stationary base so that the platen assembly may rotate relative to the base. The apparatus further includes a coupling assembly for transferring electrical energy from a primary coil to a secondary coil. The coupling assembly includes the primary coil of wire wrapped around a first core; the first core coupled to the base; the secondary coil of wire wrapped around a second core; and the second core coupled to the platen assembly.

[0013] In another embodiment, an apparatus for processing a substrate is provided. The apparatus includes a platen assembly having a surface for supporting a planarizing material and disposed on a stationary base so that the platen assembly may rotate relative to the base. The apparatus
further includes means for transferring electrical energy from the base to the platen assembly.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0014] So that the manner in which the above recited embodiments of the invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0015] **FIG. 1** is a plan view of a planarizing system;

[0016] **FIG. 2** is a sectional view of one embodiment of an electrochemical mechanical planarizing (ECMP) station that may be used with the system of **FIG. 1**;

[0017] **FIG. 3** depicts a sectional view of one embodiment of a portion of a chemical mechanical planarizing (CMP) platen assembly which may be substituted for a corresponding portion of the platen assembly of **FIG. 2** to provide a CMP station; and

[0018] **FIG. 4** is a sectional view of one embodiment of a magnetic slip ring that may be used as part of the rotary coupler of **FIG. 2**.

[0019] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

**DETAILED DESCRIPTION**

[0020] **FIG. 1** is a plan view of one embodiment of a planarizing system 100 having an apparatus for processing a substrate. The exemplary system 100 generally comprises a factory interface 102, a loading robot 104, and a planarizing module 106. The loading robot 104 is disposed proximate the factory interface 102 and the planarizing module 106 to facilitate the transfer of substrates 122 therebetween.

[0021] A controller 108 is provided to facilitate control and integration of the modules of the system 100. The controller 108 comprises a central processing unit (CPU) 110, a memory 112, and support circuits 114. The controller 108 is coupled to the various components of the system 100 to facilitate control of, for example, the planarizing, cleaning, and transfer processes.

[0022] The factory interface 102 generally includes a cleaning module 116 and one or more wafer cassettes 118. An interface robot 120 is employed to transfer substrates 122 between the wafer cassettes 118, the cleaning module 116 and an input module 124. The input module 124 is positioned to facilitate transfer of substrates 122 between the planarizing module 106 and the factory interface 102 by grippers, for example vacuum grippers or mechanical clamps.

[0023] The planarizing module 106 includes a plurality of planarizing stations 132. The stations 132 may be electrochemical mechanical planarizing (ECMP) stations, chemical mechanical planarizing (CMP) stations, or a combination of the two. Further, some of the stations 132 may be configured for bulk removal and others for residual removal. The stations 132 are disposed in an environmentally controlled enclosure 188. Examples of planarizing modules 106 that can be adapted to benefit from the invention include MIRRA®, MIRRA MESA™, REFLEXION®, REFLEXION® LK, and REFLEXION LK Eemp™ Chemical Mechanical Planarizing Systems, all available from Applied Materials, Inc. of Santa Clara, Calif. Other planarizing modules, including those that use processing pads, planarizing webs, or a combination thereof, and those that move a substrate relative to a planarizing surface in a rotational, linear or other planar motion may also be adapted to benefit from the invention.

[0024] The exemplary planarizing module 106 also includes a transfer station 136 and a carousel 134 that are disposed on an upper or first side 138 of a machine base 140. In one embodiment, the transfer station 136 includes an input buffer station 142, an output buffer station 144, a transfer robot 146, and a load cup assembly 148. The input buffer station 142 receives substrates from the factory interface 102 by the loading robot 104. The loading robot 104 is also utilized to return polished substrates from the output buffer station 144 to the factory interface 102. The transfer robot 146 is utilized to move substrates between the buffer stations 142, 144 and the load cup assembly 148.

[0025] In one embodiment, the transfer robot 146 includes two gripper assemblies, each having pneumatic gripper fingers that hold the substrate by the substrate’s edge. The transfer robot 146 may simultaneously transfer a substrate to be processed from the input buffer station 142 to the load cup assembly 148 while transferring a processed substrate from the load cup assembly 148 to the output buffer station 144.

[0026] The carousel 134 is centrally disposed on the base 140. The carousel 134 typically includes a plurality of arms 150, each supporting a planarizing head assembly 152. Two of the arms 150 depicted in **FIG. 1** are shown in phantom, such that a planarizing surface 126 of one of the planarizing stations 132 and the transfer station 136 may be seen. The carousel 134 is indexable such that the planarizing head assemblies 152 may be moved between the planarizing stations 132 and the transfer station 136.

[0027] A conditioning device 182 is disposed on the base 140 adjacent each of the planarizing stations 132. The conditioning device 182 periodically conditions the planarizing material disposed in the stations 132 to maintain uniform planarizing results.

[0028] **FIG. 2** depicts a sectional view of one of the planarizing head assemblies 152 positioned over one embodiment of an ECMP station 132. The planarizing head assembly 152 generally comprises a drive system 202 coupled to a planarizing head 204. The drive system 202 generally provides at least rotational motion to the planarizing head 204. The planarizing head 204 additionally may be actuated toward the ECMP station 132 such that the substrate 122 retained in the planarizing head 204 may be disposed against the planarizing surface 126 of the ECMP station 132 during processing. The drive system 202 is coupled to the controller 108 that provides a signal to the drive system 202 for controlling the rotational speed and direction of the planarizing head 204.

[0029] In one embodiment, the planarizing head may be a TITAN HEAD™ or TITAN PROFILER™ wafer carrier
manufactured by Applied Materials, Inc. Generally, the planarizing head 204 comprises a housing 214 and retaining ring 224 that defines a center recess in which the substrate 122 is retained. The retaining ring 224 circumscribes the substrate 122 disposed within the planarizing head 204 to prevent the substrate from slipping out from under the planarizing head 204 while processing. The retaining ring 224 can be made of plastic materials such as PPS, PEEK, and the like, or conductive materials such as stainless steel, Cu, Au, Pd, and the like, or some combination thereof. It is further contemplated that a conductive retaining ring 224 may be electrically biased to control the electric field during ECMP. It is contemplated that other planarizing heads may be utilized.

[0030] The ECMP station 132 generally includes a platen assembly 230. The platen assembly 230 is supported above the base 140 by a bearing 238 so that the platen assembly 230 may be rotated relative to the base 140. An area of the base 140 circumscribed by the bearing 238 is open and provides a conduit for the electrical, mechanical, pneumatic, control signals and connections communicating with the platen assembly 230.

[0031] Conventional bearings, rotary unions and a magnetic slip ring assembly 500 (see FIG. 4, discussed below), collectively referred to as rotary coupler 276, are provided such that electrical, mechanical, fluid, pneumatic, control signals and connections may be coupled between the base 140 and the rotating platen assembly 230. The platen assembly 230 is coupled to a motor 232 that provides the rotational motion to the platen assembly 230. The motor 232 is coupled to the controller 108 that provides a signal for controlling for the rotational speed and direction of the platen assembly 230.

[0032] The platen assembly 230 has an upper plate 236 and a lower plate 234. The upper plate 236 may be fabricated from a rigid material, such as a metal or rigid plastic, and in one embodiment, is fabricated from or coated with a dielectric material, such as CPVC. The upper plate 236 may have a circular, rectangular or other plane form. A top surface 260 of the upper plate 236 supports a processing pad assembly 222 thereon.

[0033] The lower plate 234 is generally fabricated from a rigid material, such as aluminum. In the embodiment depicted in FIG. 2, the upper and lower plates 236, 234 are coupled by a plurality of fasteners 228. Generally, a plurality of locating pins 220 (one is shown in FIG. 2) are disposed between the upper and lower plates 236, 234 to ensure alignment therebetween. The upper plate 236 and the lower plate 234 may optionally be fabricated from a single, unitary member.

[0034] Optionally, a magnetic element 240 may be disposed within the platen assembly 230 and is adapted to urge the processing pad assembly 222 toward the platen assembly 230. The magnetic element 240 is coupled to a power source 244 through the rotary coupler 276. It is contemplated that the magnetic element 240 may be coupled to the pad assembly 222 such that the pad assembly 222 is attracted to the platen assembly 230.

[0035] In the embodiment of FIG. 2, the magnetic element 240 is magnetically coupled to the conductive material (i.e., metallic material) disposed in, on or coupled to the processing pad assembly 222. The magnetic attraction between the magnetic element 240 and processing pad assembly 222 pulls the processing pad assembly 222 against the top surface 260 of the platen assembly 230 such that the processing pad assembly 222 advantageously remains stationary relative to the platen assembly 230 during processing.

[0036] The magnet element 240 is generally disposed parallel to the top surface 260 of the platen assembly 230. This orientation generally enhances force uniformity of the processing pad assembly 222 against the top surface 260 of the platen assembly 230.

[0037] In one embodiment, the magnetic element 240 is an electromagnet disposed between the upper plate 236 and the lower plate 234 of the platen assembly 230. The magnetic element 240 may be selectively energized by the power source 244 to create a bias force attracting the processing pad assembly 222 to the platen assembly 230. As the magnetic force applied by the magnetic element 240 is easily regulated by the power source 244, the contact force between the processing pad assembly 222 and the platen assembly 230 may be optimally tailored for specific processing routines. Moreover, the attraction force between the processing pad assembly 222 and the platen assembly 230 may be removed by interrupting power applied to the magnetic element 240, the processing pad assembly 222 may be easily separated from the platen assembly 230. Optionally, the polarity of the magnetic force generated by the magnetic element 240 may be reversed to assist removing the processing pad assembly 222 in instances where the processing pad assembly 222 has become magnetized and/or contains permanent magnetic material. Alternatively, the magnetic element 240 may be a permanent magnet.

[0038] It is contemplated that the magnetic element 240 may be disposed in other positions within or adjacent the platen assembly 230. It is also contemplated that planarizing material support surfaces of planarizing stations having alternative and diverse designs may be adapted to incorporate a magnetic element 240 to provide an attractive force for securing a processing pad assembly 222 to the surface supporting the processing pad assembly.

[0039] The platen assembly 230 may optionally include a vacuum port 280 disposed in the top surface 250 of the platen assembly 230 supporting the processing pad assembly 222. The vacuum port 280 is coupled to a vacuum source 246 configured to selectively apply a vacuum to retain the processing pad assembly 222 against the platen assembly 230.

[0040] A plenum 206 is defined in the platen assembly 230. The plenum 206 may be partially formed in at least one of the upper or lower plates 236, 234. In the embodiment depicted in FIG. 2, the plenum 206 is defined in a recess 208 partially formed in the lower surface 262 of the upper plate 236. A plurality of holes 210 are formed in the upper plate 236 to allow electrolyte, provided to the plenum 206 from an electrolyte source 248, to flow uniformly through the platen assembly 230 and into contact with the substrate 122 during processing. The plenum 206 is partially bounded by a cover 212 coupled to the upper plate 236 enclosing the recess 208.

[0041] The processing pad assembly 222 includes an electrode 292 and at least a planarizing portion 290. At least
one contact assembly 250 extends above the processing pad assembly 222 and is adapted to electrically couple the substrate being processing on the processing pad assembly 222 to the power source 244.

[0042] The electrode 292 is also coupled to the power source 244 so that an electrical potential may be established between the substrate and electrode 292. The electrode 292 is typically comprised of a conductive material, such as stainless steel, copper, aluminum, gold, silver and tungsten, among others. The electrode 292 may be solid, impermeable to electrolyte, permeable to electrolyte or perforated. The electrode 292 may be permeable, have holes formed therethrough or a combination thereof. The electrode 292 is disposed on the top surface 260 of the platen assembly 230 and is coupled to the power source 244 through the platen assembly 230.

[0043] Embodiments of the processing pad assembly 222 suitable for bulk removal of material from the substrate 122 may generally include a planarizing surface that is substantially dielectric. As the conductive material to be removed from the substrate 122 substantially covers the substrate 122, fewer contacts for biasing the substrate 122 are required. Embodiments of the processing pad assembly 222 suitable for residual removal of material from the substrate 122 may generally include a planarizing surface that is substantially conductive. As the conductive material to be removed from the substrate 122 comprises isolated islands of material disposed on the substrate 122, more contacts for biasing the substrate 122 are required. In one embodiment, the planarizing layer 290 of the processing pad assembly 222 may include a planarizing surface that is dielectric, such as a polyurethane pad.

[0044] The platen assembly 230 may include a sonic transducer 254 coupled thereto. The transducer 254 is adapted to vibrate the platen assembly 230, thereby inducing movement and/or rotation of a ball of the contact assembly 250. The transducer 254 may be activated during idle periods between substrate planarizing to induce ball motion within the contact assembly 250, thereby reducing the effects of processing chemistry on the ball. Alternatively, a rotating disk made from soft materials compatible with processing chemistry, such as PEEK, PPS, can cover that contact assemblies during idle period to induce the rotation of the balls, thus minimize the static chemical attack on the balls.

[0045] Optionally, the platen assembly 230 may include a sacrificial metal 258 disposed therein. The sacrificial metal 258 may be exposed through an aperture, depression or slot 256 in the top surface 260 of the platen assembly 230. The sacrificial metal 258 may be positioned near or remote from the contact assemblies 250, as long as process chemistries disposed on a top surface of the planarizing portion 290 may contiguously wet the sacrificial metal 258 and the ball. The sacrificial metal 258 is additionally electrically coupled to the ball through the platen assembly 230. The sacrificial metal 258 is formed of a material, for example zinc, that is preferentially reactive with the process chemistries relative to the material comprising the outer surface of the ball, thereby minimizing the attack on the ball by process chemistries. The means for protecting the ball described in herein can be utilized separately or together to protect the ball from chemical attack by the processing chemistry.

[0046] FIG. 3 depicts a sectional view of one embodiment of a portion of a CMP platen assembly 330. The portion of CMP platen assembly 330 may be substituted for a corresponding portion of the platen assembly 230 of FIG. 2 to provide a CMP station 132. Since, in this embodiment, a vacuum system 382 (see below) is provided within the platen assembly 330, no vacuum source 246 is required. Also, a planarizing fluid source 248 would substitute for the electrolyte source 248.

[0047] Generally, a CMP process is performed at each CMP station 132 by moving the substrate 122 retained in the planarizing head assembly 152 relative to the planarizing material 302 supported on the CMP station 132. The planarizing material 302 may have a smooth surface, a textured surface, a surface containing abrasives or a combination thereof. Additionally, the planarizing material 302 may be advanced across or releasably fixed to the planarizing surface. Typically, the planarizing material 302 is releasably fixed by adhesives, vacuum, mechanical clamps or by other holding methods to the CMP station 132.

[0048] The planarizing material 302 may comprise a pad or a web. In the embodiment depicted in FIG. 3, the planarizing material 302 comprises abrasive sheet material. Abrasive sheet material generally includes a plurality of abrasive particles suspended in a resin binder that is disposed in discrete elements on a backing sheet. The web of planarizing material 302 may optionally comprise conventional planarizing material without abrasives, for example, polyurethane foam available from Rodel Inc., of Newark, Del.

[0049] The platen assembly 330 generally includes a top surface 360, a first end 310, a second end 312 and a bottom surface 362. The top surface 360 generally has a hollow center passage 376 formed therethrough. The center passage 376 allows for fluid, electrical, sensor, control and other lines to be routed from the rotary coupler 276 to different areas of the platen assembly 330.

[0050] A first cavity 324 and at least a second cavity 326 are disposed in the platen assembly 330 between the center passage 376 and a respective end 310, 312. The first cavity 324 generally houses a vacuum system 382 that is utilized to secure and optionally space the planarizing material 302 from the platen assembly 330. The first cavity 324 generally includes a passage 344 disposed through the platen assembly 330 that connects the first cavity 324 to the bottom surface 362 of the platen assembly 330. The passage 344 allows air, liquids and other contaminates exiting the vacuum system 382 to flow out the bottom surface 362 of the platen assembly 330 and be captured by the system's central waste system (not shown) that is typically disposed in or on the base 140.

[0051] The second cavity 326 generally houses a printed circuit board (PCB) 314 that controls or interfaces with the vacuum system 382 and/or other devices disposed in the platen assembly 330. The geometry of the platen assembly 330, including the size and location of the cavities 324 and 326, along with the size, weight and location of the vacuum system 382 and PCB 314 are configured to substantially balance the platen 330 as the platen rotates. The rotational balance of the platen 330 extends the life of the bearing 304 while reducing vibration and runout of the platen 230 while rotating, thus enhancing planarizing performance. Alternati-
tively, the vacuum system 382 may be coupled to the bottom surface 362 of the platen assembly 330, disposed in another position proximate the platen assembly 330 or disposed remotely from the assembly 330.

[0052] A first side rail 316 is coupled to the first end 310 while a second side rail 318 is coupled to the second end 312 of the platen assembly 330. The rails 316, 318 support a web supply assembly (not shown) and a web take-up assembly (not shown).

[0053] A top plate 308 is generally disposed on the top surface 360 spanning the center passage 376. A subpad 378 and a subplate 380 are disposed on a center portion 394 of the top plate 308 and support the planarizing material 302 thereon. The subpad 378 is typically a plastic, such as polycarbonate or foamed polyurethane. Generally, the hardness or durometer of the subpad 378 may be chosen to produce a particular planarizing result. The subpad 378 generally maintains the planarizing material 302 parallel to the plane of the substrate 322 held in the planarizing head assembly 152 and promotes global planarizing of the substrate 122. The subplate 380 is positioned between the subpad 378 and the bottom of the center passage 376 such that the upper surface of the subpad 378 is maintained coplanar with the top surface 360 of the platen 330.

[0054] Generally, the subpad 378 and subplate 380 contain a plurality of concentric passages or apertures 396 disposed therethrough. The apertures 396 allow a vacuum to be pulled through the subpad 378 thus securing the planarizing material 302 thereto during processing.

[0055] The top plate 308 generally includes an annular gasket 388 disposed thereon that circumscribes the center portion 394 that supports the subpad 378 and subplate 380. The gasket 388 may be any form of seal such as a polymer sheet, O-ring or molded form, including those comprising spring elements. Generally, the gasket 388 is configured to have a height that extends above the subpad 378. In one embodiment, the gasket 388 has a parabolic shape which minimizes the contact area with the planarizing material 302 when vacuum is applied to secure the planarizing material 302. The gasket 388 is generally fabricated from a fluoropolymer, EPDM, EPR, VITON® or other elastomeric material compatible with the planarizing fluids and able to substantially provide a vacuum seal against the backing material of the planarizing material 102.

[0056] The gasket 388 is secured to the top plate 308 in a manner that prevents the gasket 388 from becoming dislodged as the planarizing material 302 is advanced across the platen assembly 330. For example, the gasket 388 may be press fit to the top plate 308, adhered to the top plate 308, vulcanized to the top plate 308, clamped to the top plate 308 or secured in another manner that prevents the gasket 388 from rolling or twisting or becoming unattached from the top plate 308 as the web of planarizing material 302 is indexed. The gasket 388 should resist abrasion and particulate generation as the planarizing material 302 is moved thereover.

[0057] An O-ring 386 or other seal is disposed between the top plate 308 and platen assembly 330 to prevent fluids or other contamination from entering the center passage 376. The top plate 308 is typically removably fastened to the platen assembly 330 by one or more fasteners 374 to allow the top plate 308 to be removed for cleaning, replacement or to allow access to the center passage 376.

[0058] The top plate 308 generally includes a vacuum port 384 therethrough which is coupled to a vacuum system 382. The vacuum system 382 generally applies a vacuum through the vacuum port 384 which evacuates a region between the planarizing material 302 and the subpad 378 as fluids are pulled through the apertures 396 and out the vacuum port 384.

[0059] A network of open channels or grooves 322 are disposed generally disposed between the top plate 308 and subplate 380 to enhance the uniformity of the vacuum applied through the subpad 378. Typically, the grooves 322 are formed in the top plate 308 but may alternatively be partially or completely formed in the subplate 380.

[0060] The vacuum port 384 is generally fluidly coupled through the grooves 322 disposed in the top plate 308 and apertures 396 disposed through subpad 378 and subplate 380 to the top surface 360. When a vacuum is drawn through the vacuum port 384, the air removed from between region of the subpad 378 and the planarizing material 302 bonded by the gasket 388 causes the planarizing material 302 to be firmly secured to the subpad 378 during planarizing. Other types of devices may be utilized to releasably fix the planarizing material 302 to the platen assembly 330, for example releasable adhesives, bonding, electrostatic clucks, mechanical clamps and other releasable retention mechanisms.

[0061] FIG. 4 is a sectional view of one embodiment of a magnetic slip ring assembly 500 that may be used as part of the rotary coupler 276 of FIG. 2. The magnetic slip ring assembly 500 includes a rotating subassembly, stationary subassembly, and a bearing subassembly. The rotating subassembly is supported on the stationary subassembly by the bearing subassembly so that the rotating subassembly may rotate relative to the stationary subassembly. The bearing subassembly includes ball bearings 515a,b and bearing spacer 502.

[0062] The rotating subassembly includes a hub 505, a rotor housing 565, a cable housing 540, an inner core 535, a secondary coil 530, an inner core retainer 570, a rotor PCB 575a, a rotor infrared (IR) transmitter/receiver 580a, cable connectors 555c,d, cables 585c,d, and threaded fasteners 595c. The hub 505 has a central longitudinal threaded bore therethrough. The hub has a cylindrical portion 505a and a hexagonal lug portion 505a. The lug portion 505a and the threaded bore of the hub 505 are for coupling to the platen assemblies 230,330. The hub 505 further includes a shoulder which abuts a housing of bearing 515a. The hub 505 further includes a plurality of holes distal from the center of the hub which receive fasteners 595c. The rotor housing 565 includes a plurality of threaded holes distal from the center of the rotor housing which correspond to the holes in the hub 505 and also receive fasteners 595b,c, thereby coupling the hub 505 to the rotor housing.

[0063] The rotor housing 565 is a cylindrical member with a central longitudinal bore therethrough which is larger in diameter than the hub bore. The enlarged rotor housing bore receives the cable housing 540. The rotor housing bore is threaded and mates with a corresponding threaded upper portion of the cable housing 540, thereby coupling the rotor
housing 565 to the cable housing. The rotor housing 565 further includes a lip which abuts a housing of bearing 515b. The bearing subassembly is disposed between the shoulder of the hub 505 and the lip of the rotor housing 565 and along outer surfaces of the hub and rotor housing. The cable housing 540 is a cylindrical member with a central longitudinal bore therethrough. The cable housing 540 has a central portion and upper and lower portions which have reduced outside diameters relative to the central portion and are threaded on outside surfaces thereof.

[0064] The inner core retainer 570 is a cylindrical member with a central longitudinal threaded bore therethrough which mates with the threaded lower portion of the cable housing 540, thereby coupling the inner core retainer to the cable housing. The inner core retainer 570 has a notch in an outer surface thereof which receives the cable connector 555d. Disposed on a bottom surface of the inner core retainer 570 is the rotor PCB 575a. Disposed on the rotor PCB 575a is the rotor IR transmitter/receiver 580a and cable connector 555c. A top surface of the inner core retainer 570 abuts a bottom surface of the inner core 535. The inner core 535 is disposed along an outer side of the central portion of the cable housing 540. The inner core 535 is a spool shaped member having the secondary coil 530 wrapped therearound. The secondary coil 530 is a length of wire made from a conductive material, for example, copper, copper alloy, aluminum, or aluminum alloy. A top surface of the inner core 535 abuts the bottom surface of the rotor housing 565.

[0065] Cable connectors 555c,d and cable 585a,d electrically couple the secondary coil 530 to a rectifier and DC voltage regulator and the rectifier and DC voltage regulator to the rotor PCB 575a. Alternatively, the rectifier and DC voltage regulator may be located on the rotor PCB 575a. Cable connectors 555c and cable 585c provide a data path between the rotor PCB 575a and various equipment, described above, disposed on platen assemblies 230,330.

[0066] The stationary subassembly includes a top cover 510, a stator housing 550, the outer core 520, the primary coil 525, an outer core retainer 560, a bottom cover 590, a stator PCB 575b, a stator IR transmitter/receiver 580b, cable connectors 555a,b, cables 585a,b, and threaded fasteners 595a,d,e,f,g,h. The top cover 510 is a cylindrical member with a central longitudinal bore therethrough. The top cover 510 includes a shoulder on an inner surface thereof which abuts a housing of bearing 515a. The top cover 510 further includes a plurality of holes distal from the center thereof which receive fasteners 595a,d. An upper portion of the stator housing 550 includes a plurality of threaded holes distal from the center thereof which correspond to the holes in the top cover 510 and also receive fasteners 595a,d, thereby coupling the top cover 510 to the stator housing.

[0067] The stator housing 550 is a cylindrical member with a central longitudinal bore therethrough. Preferably, stator housing 550 is made from a non-ferrous material. The stator housing 550 has a central portion, the upper portion, and a lower portion. The upper portion has a reduced inside diameter relative to the central portion and the lower portion has an increased inside diameter relative to the central portion. The stator housing 550 further includes a lip which, on a top side, abuts a housing of bearing 515b. The bearing subassembly is disposed between the shoulder of the top cover 510 and the lip of the stator housing 550 and along inner surfaces of the top cover and stator housing. A bottom side of the stator housing lip abuts a top side of the outer core 520.

[0068] The outer core 520 is disposed along an inner side of the central portion of the stator housing 550. The outer core 520 is a spool shaped member having the primary coil 525 wrapped therearound. The outer core 520 is made from a magnetic material, such as silicon steel. The primary coil 525 is a length of wire made from a conductive material, for example, copper, copper alloy, aluminum, or aluminum alloy. The outer core 520 is longitudinally aligned with and in radial proximity to the inner core 535. Abutting a bottom surface of the outer core 520 is the outer core retainer 560.

[0069] The outer core retainer 560 is a cylindrical member with a central longitudinal bore therethrough. The outer core retainer 560 further includes a plurality of holes distal from the center thereof which receive fasteners 595e,f. The central portion of the stator housing 550 includes a plurality of threaded holes distal from the center thereof which correspond to the holes in the outer core retainer 560 and also receive fasteners 595e,f, thereby coupling the outer core retainer 560 to the stator housing. The core retainer also includes a hole which receives the cable connector 555b.

[0070] Abutting a bottom surface of the lower portion of the stator housing 550 is the bottom cover 590. The bottom cover 590 is a cylindrical member and includes a plurality of holes distal from the center thereof which receive fasteners 595g,h. The lower portion of the stator housing 550 includes a plurality of threaded holes distal from the center thereof which correspond to the holes in the bottom cover 590 and also receive fasteners 595g,h, thereby coupling the bottom cover to the stator housing. The bottom plate 590 also includes a hole which receives the cable connector 555a.

[0071] Cable connectors 555a,b and cable 585a,d electrically couple the primary coil 525 to the power source 244. Cable connector 555a and cable 585b provide a data path between the rotor PCB 575b and the controller 108.

[0072] In general, the magnetic slip ring assembly 500 acts similar to a common transformer in that it employs electromagnetic induction to transfer electrical energy from one circuit, via its primary coil, to another, via its secondary coil, and does so without mechanical contact between circuits. However, unlike the common transformer, the secondary coil 530 of the magnetic slip ring assembly 500 rotates. The parameters of the magnetic slip ring assembly 500 are primarily defined by the application in which it is used, but only the size and cooling of the magnetic slip ring assembly 500 limit the voltage, current and frequency of the power that it may transfer.

[0073] In operation, an alternating current is supplied to the primary coil 525 by the power source 244. When the alternating current flows through the primary coil 525, the resulting magnetic flux in the inner core 535 and outer core 520 induces an alternating current across secondary coil 530. A constant power is transmitted to the rectifier and DC voltage regulator, even though the secondary coil 530 is
rotating. The inner core 535 and outer core 520 close the magnetic dipole fields associated with magnetic flux created by the application of alternating current across the primary coil 525. This closure results in efficient coupling between the primary coil 525 and secondary coil 530. The primary coil 525 and secondary coil 530 have their parameters, for example, number of wrapped wires, selected so that an appropriate voltage may be generated by the AC power source 244 and applied to the primary coil 525 to develop an output signal across the secondary coil 530. The rectifier and DC voltage regulator are conventional.

[0074] The IR transmitters/receivers 580a,b and respective PCBs 575a,b allow the controller 108 to communicate with the various equipment on the platen assemblies 230, 330.

[0075] Unlike conventional slip rings, the magnetic slip ring assembly 500 is devoid of any mechanical contact between its components that are connected to the stationary base 140 and the rotating platen assemblies 230,330. The contactless magnetic slip ring 500 does not suffer the drawbacks of conventional slip rings burdened with moving surfaces. Conventional slip rings are subjected to debris and arcing conditions which might cause relatively high noise levels to be encountered or even momentary loss of the electrical signals that are being transferred between the stationary and rotating equipment.

[0076] While the foregoing is directed to embodiments of the invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow. For example, the components of the magnetic slip ring assembly 500 may be other shapes than cylindrical, such as polygonal.

What is claimed is:

1. An apparatus for processing a substrate, comprising:
   a platen assembly having a surface for supporting a planarizing material and disposed on a stationary base so that the platen assembly may rotate relative to the base; and
   a coupling assembly for transferring electrical energy from a primary coil to a secondary coil, comprising:
   the primary coil of wire wrapped around a first core; the first core coupled to the base;
   the secondary coil of wire wrapped around a second core; and
   the second core coupled to the platen assembly.

2. The apparatus of claim 1, wherein the coupling assembly further comprises:
   an IR transmitter and receiver coupled to the base; and
   an IR transmitter and receiver coupled to the platen assembly.

3. The apparatus of claim 1, wherein the first core is substantially longitudinally aligned with the second core.

4. The apparatus of claim 1, further comprising:
   a plenum defined within the platen assembly; and
   a plurality of passages formed through the platen assembly coupling the support surface to the plenum.

5. The apparatus of claim 4, wherein the platen assembly further comprises a top plate that includes the top surface and having at least a first portion of each of the passages formed therethrough.

6. The apparatus of claim 5, wherein the platen assembly further comprises
   a conductive contact plate disposed opposite a surface of the top plate having the processing pad disposed thereon and electrically coupled to the conductive elements, the conductive contact plate having at least a second portion of each of the passages formed therethrough.

7. The apparatus of claim 4, further comprising an electrode disposed on the platen assembly.

8. The apparatus of claim 1, further comprising:
   a processing pad disposed on the platen assembly and having an upper dielectric processing surface adapted to process the substrate thereon; and
   one or more conductive elements arranged on the upper processing surface to electrically bias the substrate.

9. An apparatus for processing a substrate, comprising:
   a platen assembly having a surface for supporting a planarizing material and disposed on a stationary base so that the platen assembly may rotate relative to the base; and
   means for transferring electrical energy from the base to the platen assembly.

10. The apparatus of claim 9, further comprising means for transferring data between the base and the platen assembly.

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