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Title: PAD CONDITIONER AUTO DISK CHANGE

Abstract: A method and apparatus for replacing a polishing pad conditioning disk is a chemical mechanical polishing system is provided. The apparatus comprises a disk load/unload station for unloading used conditioning disks from a pad conditioning assembly and loading unused conditioning disks onto the pad conditioning assembly, on or more disk storage stations for storing both used and unused conditioning disks, and a central robot having a range of motion sufficient for transferring both used an unused conditioning disks between the disk load/unload station and the one or more disk storage stations. Embodiments described herein reduce the length of system interruption by eliminating the need to safety lock out the system for the replacement of polishing pad conditioning disks.
PAD CONDITIONER AUTO DISK CHANGE

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] Embodiments described herein generally relate to the planarization of substrates. More particularly, the embodiments described herein relate to the conditioning of polishing pads.

Description of the Related Art

[0002] Sub-quarter micron multi-level metallization is one of the key technologies for the next generation of ultra large-scale integration (ULSI). The multilevel interconnects that lie at the heart of this technology require planarization of interconnect features formed in high aspect ratio apertures, including contacts, vias, trenches and other features. Reliable formation of these interconnect features is very important to the success of ULSI and to the continued effort to increase circuit density and quality on individual substrates and die.

[0003] Multilevel interconnects are formed using sequential material deposition and material removal techniques on a substrate surface to form features therein. As layers of materials are sequentially deposited and removed, the uppermost surface of the substrate may become non-planar across its surface and require planarization prior to further processing. Planarization or "polishing" is a process in which material is removed from the surface of the substrate to form a generally even, planar surface. Planarization is useful in removing excess deposited material, removing undesired surface topography, and surface defects, such as surface roughness, agglomerated materials, crystal lattice damage, scratches, and contaminated layers or materials to provide an even surface for subsequent photolithography and other semiconductor manufacturing processes.

[0004] Chemical Mechanical Planarization, or Chemical Mechanical Polishing (CMP), is a common technique used to planarize substrates. CMP utilizes a chemical composition, such as slurries or other fluid medium, for selective removal of materials from substrates. In conventional CMP techniques, a substrate carrier or polishing head is mounted on a carrier assembly and positioned in contact with a
polishing pad in a CMP apparatus. The carrier assembly provides a controllable pressure to the substrate, thereby pressing the substrate against the polishing pad. The pad is moved relative to the substrate by an external driving force. The CMP apparatus affects polishing or rubbing movements between the surface of the substrate and the polishing pad while dispersing a polishing composition to affect chemical activities and/or mechanical activities and consequential removal of materials from the surface of the substrate.

[0005] The polishing pad performing this removal of material must have the appropriate mechanical properties for substrate planarization while minimizing the generation of defects in the substrate during polishing. Such defects may be scratches in the substrate surface caused by raised areas of the pad or by polishing by-products disposed on the surface of the pad, such as accumulation of conductive material removed from the substrate precipitating out of the electrolyte solution, abraded portions of the pad, agglomerations of abrasive particles from polishing slurries, and the like. The polishing potential of the polishing pad generally lessens during polishing due to wear and/or accumulation of polishing by-products on the pad surface, resulting in sub-optimum polishing qualities. This sub-optimization of the polishing pad may occur in a non-uniform or localized pattern across the pad surface, which may promote uneven planarization of the conductive material. Thus, the pad surface must periodically be refreshed, or conditioned, to restore the polishing performance of the pad.

[0006] Therefore, there is a need for improved methods and apparatus for conditioning polishing pads.

**SUMMARY OF THE INVENTION**

[0007] Embodiments described herein generally relate to the planarization of substrates. More particularly, the embodiments described herein relate to the conditioning of polishing pads. In one embodiment an apparatus for replacing a polishing pad conditioning disk is a chemical mechanical polishing system is provided. The apparatus comprises a disk load/unload station for unloading used conditioning disks from a pad conditioning assembly and loading unused
conditioning disks onto the pad conditioning assembly, one or more disk storage stations for storing both used and unused conditioning disks, and a central robot having a range of motion sufficient for transferring both used and unused conditioning disks between the disk load/unload station and the one or more disk storage stations.

[0008] In another embodiment a system for chemical mechanical polishing of a substrate is provided. The system comprises a platen assembly, a polishing surface supported on the platen assembly, one or more polishing heads on which substrates are retained while polishing, a pad conditioning assembly for dressing the polishing surface by removing polishing surface by removing polishing debris and opening the pores of the polishing surface, and an auto disk changer module for replacing a polishing pad conditioning disk.

[0009] In yet another embodiment a method for replacing a polishing pad conditioning disk in a chemical mechanical polishing system is provided. The method comprises unloading a used conditioning disk from a pad conditioning assembly at a disk load/unload station, retrieving the used conditioning disk with a central robot, transferring the used conditioning disk using the central robot from the disk load/unload station to one or more disk storage stations, unloading the used conditioning disk, retrieving an unused conditioning disk from the one or more disk storage stations, transferring the unused conditioning disk using the central robot to the load/unload station, and loading the unused conditioning disk onto the pad conditioning assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of 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.
FIG. 1 is a top plan view of one embodiment of a chemical mechanical polishing system;

FIG. 2 is a partial perspective view of a polishing station of FIG. 1;

FIG. 3 is a top schematic view of the auto disk changer module of FIG. 2;

FIG. 4 is a side schematic view of a disk load/unload pedestal;

FIG. 5 is a top schematic view of another embodiment of an auto disk changer module;

FIG. 6 is a top schematic view of another embodiment of an auto disk changer module;

FIG. 7 is a top schematic view of another embodiment of a polishing station of a chemical mechanical polishing system; and

FIG. 8 is a side view of one embodiment of a pad conditioning assembly.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements disclosed in one embodiment may be beneficially utilized on other embodiment without specific recitation.

DETAILED DESCRIPTION

Embodiments described herein generally relate to the planarization of substrates. More particularly, the embodiments described herein relate to the conditioning of polishing pads. A conventional pad conditioning apparatus places an abrasive material in contact with a moving polishing pad. For example, a pad conditioning disk may be used to scrape and abrade the pad surface, and to expand and re-roughen the pad. The pad conditioning disk may be coupled with a rotatable backing element.

Replacement of pad conditioning disks is a time consuming process that reduces system availability. Currently, the pad conditioning disk is manually
replaced about every 15 to 30 hours. The existing manual replacement process requires safety lock out and tag out of the system so the operator can physically enter the processing environment. Embodiments described herein will greatly extend the time required between operator intervention with the system. Embodiments described herein automate the conditioning disk replacement process, reducing the length of system interruption by eliminating the need to safety lock out the system for the manual conditioning disk change. Embodiments described herein also enable the use of different types of conditioning disks during the polishing process. For example, an aggressive diamond conditioning disk may be used for pad break-in, a less aggressive diamond conditioning disk may be used for pad conditioning, and a brush disk for pad cleaning.

[0022] In one embodiment, the pad conditioning arm discards a used conditioning disk at one location and retrieves an unused conditioning disk from another location. In one embodiment, the locations each comprise a conditioning disk holder which holds a vertical stack of conditioning disks. In another embodiment, the unused disk stack may be located vertically above the old disk stack, reducing the system footprint. In one embodiment, the conditioning disk may be coupled with and decoupled from the pad conditioning arm by actuators located on the pad conditioning arm or actuators located on the disk stack. In another embodiment, coupling and decoupling of the conditioning disk from the pad conditioning arm may be accomplished by passive mechanisms taking advantage of the existing up and down motion of the pad conditioning arm.

[0023] In another embodiment, the auto conditioning disk change may be accomplished by carrying spare conditioning disks on the pad conditioning arm. In one embodiment, the pad conditioning arm may index between pad conditioning disks to extend the useable life of each conditioning disk. For example, the spare conditioning disks may be raised above the platen and not used until the active conditioning disk reaches the end of its life. Alternatively, the multiple conditioning disks may be cycled in and out at high frequency to average out variations in conditioning disk quality.
While the particular apparatus in which the embodiments described herein can be practiced is not limited, it is particularly beneficial to practice the embodiments in a REFLEXION Lk CMP system and MIRRA MESA® system sold by Applied Materials, Inc., Santa Clara, Calif. Additionally, CMP systems available from other manufacturers may also benefit from embodiments described herein. Embodiments described herein may also be practiced on overhead circular track polishing systems including the overhead circular track polishing systems described in United States Provisional Patent Application No. 61/043,582 (Attorney Docket No. 013036L), titled CIRCULAR TRACK POLISHING SYSTEM ARCHITECTURE and United States Provisional Patent Application No. 61/043,600 (Attorney Docket No. 013194L), titled POLISHING HEAD FOR A TRACK SYSTEM both of which are hereby incorporated by reference in their entirety.

FIG. 1 is a top plan view illustrating one embodiment of a chemical mechanical polishing ("CMP") system 100 comprising an auto disk changer module 150 for automatic replacement of pad conditioning disks. The CMP system 100 includes a factory interface 102, a cleaner 104 and a polishing module 106. A wet robot 108 is provided to transfer substrates 170 between the factory interface 102 and the polishing module 106. The wet robot 108 may also be configured to transfer substrates between the polishing module 106 and the cleaner 104. The factory interface 102 includes a dry robot 110 which is configured to transfer substrates 170 between one or more cassettes 114 and one or more transfer platforms 116. In one embodiment depicted in FIG. 1, four substrate storage cassettes 114 are shown. The dry robot 110 has sufficient range of motion to facilitate transfer between the four cassettes 114 and the one or more transfer platforms 116. Optionally, the dry robot 110 may be mounted on a rail or track 112 to position the robot 110 laterally within the factory interface 102, thereby increasing the range of motion of the dry robot 110 without requiring large or complex robot linkages. The dry robot 110 additionally is configured to receive substrates from the cleaner 104 and return the clean polished substrates to the substrate storage cassettes 114. Although one substrate transfer platform 116 is shown in the embodiment depicted in FIG. 1, two or more substrate transfer platforms may be provided so that at least two substrates
may be queued for transfer to the polishing module 106 by the wet robot 108 at the same time.

[0026] Still referring to FIG. 1, the polishing module 106 includes a plurality of polishing stations 124 on which substrates are polished while retained in one or more polishing heads 126. The polishing stations 124 are sized to interface with two or more polishing heads 126 simultaneously so that polishing of two or more substrates may occur using a single polishing station 124 at the same time. The polishing heads 126 are coupled to a carriage (not shown) that is mounted to an overhead track 128 that is shown in phantom in FIG. 1. The overhead track 128 allows the carriage to be selectively positioned around the polishing module 106 which facilitates positioning of the polishing heads 126 selectively over the polishing stations 124 and load cup 122. In the embodiment depicted in FIG. 1, the overhead track 128 has a circular configuration which allows the carriages retaining the polishing heads 126 to be selectively and independently rotated over and/or clear of the load cups 122 and the polishing stations 124. The overhead track 128 may have other configurations including elliptical, oval, linear or other suitable orientation and the movement of the polishing heads 126 may be facilitated using other suitable devices.

[0027] In one embodiment depicted in FIG. 1, two polishing stations 124 are shown located in opposite corners of the polishing module 106. At least one load cup 122 is in the corner of the polishing module 106 between the polishing stations 124 closest the wet robot 108. The load cup 122 facilitates transfer between the wet robot 108 and the polishing head 126. Optionally, a third polishing station 124 (shown in phantom) may be positioned in the corner of the polishing station 124 opposite the load cups 122. Alternatively, a second pair of load cups 122 (also shown in phantom) may be located in the corner of the polishing module 106 opposite the load cups 122 that are positioned proximate the wet robot. Additional polishing stations 124 may be integrated in the polishing module 106 in systems having a larger footprint.

[0028] Each polishing station 124 includes a polishing surface 130 capable of polishing at least two substrates at the same time and a matching number of
polishing units for each of the substrates. Each of the polishing units includes a polishing head 126, a conditioning module 132, a polishing fluid delivery module 134, and an auto disk changer module 150. In one embodiment, the conditioning module 132 may comprise a pad conditioning assembly 140 which dresses the pad by removing polishing debris and opening the pores of the pad. In another embodiment, the polishing fluid delivery module 134 may comprise a slurry delivery arm. In one embodiment, each polishing station 124 comprises multiple pad conditioning assemblies 132, 133. In one embodiment, each polishing station 124 comprises multiple fluid delivery arms 134, 135 for the delivery of a fluid stream to each polishing stations 124. The polishing surface 130 is supported on a platen assembly 202 (see FIG. 2) which rotates the polishing surface 130 during processing. In one embodiment, the polishing surface 130 is suitable for at least one of a chemical mechanical polishing and/or an electrochemical mechanical polishing process. In another embodiment, the platen may be rotated during polishing at a rate from about 10 rpm to about 150 rpm, for example, about 50 rpm to about 110 rpm, such as about 80 rpm to about 100 rpm.

[0029] Each conditioning module 132 includes a pad conditioning assembly 140. The pad conditioning assembly 140 comprises a conditioning head 142 supported by a support assembly 146 with a support arm 144 therebetween. The support assembly 146 is coupled with a base 147 and is adapted to position the conditioning head 142 in contact with the polishing surface 130, and further is adapted to provide a relative motion therebetween. The support arm 144 has a distal end coupled to the conditioning head 142 and a proximal end coupled to the base 147. The base 147 rotates to sweep the conditioning head 142 across the polishing surface 130 to condition the polishing surface 130. The conditioning head 142 is also configured to provide a controllable pressure or downforce to controllably press the conditioning head 142 toward the polishing surface 130. The downforce pressure can be in a range between about 0.5 psi to about 20 psi, for example, between about 1 psi and about 14 psi. The conditioning head 142 generally rotates and/or moves laterally in a sweeping motion across the polishing surface 130. In one embodiment, the lateral motion of the conditioning head 142 may be linear or along an arc in a range of about the center of the polishing surface 130 to about the outer edge of the polishing
surface 130, such that, in combination with the rotation of the platen assembly 202, the entire surface polishing surface 130 may be conditioned. The conditioning head 142 may have a further range of motion to move the conditioning head 142 off of the platen assembly 202 when not in use.

[0030] The conditioning head 142 is adapted to house a conditioning disk 148 to contact the polishing surface 130. The conditioning disk 148 may be coupled with the conditioning head 142 by passive mechanisms such as magnets and pneumatic actuators that take advantage of the existing up and down motion of the support arm 144. The conditioning disk 148 generally extends beyond the housing of the conditioning head 142 by about 0.2 mm to about 1 mm in order to contact the polishing surface 130. The conditioning disk 148 can be made of nylon, cotton cloth, polymer, or other soft material that will not damage the polishing surface 130. Alternatively, the conditioning disk 148 may be made of a textured polymer or stainless steel having a roughened surface with diamond particles adhered thereto or formed therein. The diamond particles may range in size between about 30 microns to about 100 microns.

[0031] To facilitate control of the polishing system 100 and processes performed thereon, a controller 190 comprising a central processing unit (CPU) 192, memory 194, and support circuits 196, is connected to the polishing system 100. The CPU 192 may be one of any form of computer processor that can be used in an industrial setting for controlling various drives and pressures. The memory 194 is connected to the CPU 192. The memory 194, or computer-readable medium, may be one or more of readily available memory such as random access memory (RAM), read only memory (ROM), floppy disk, hard disk, or any other form of digital storage, local or remote. The support circuits 196 are connected to the CPU 192 for supporting the processor in a conventional manner. These circuits include cache, power supplies, clock circuits, input/output circuitry, subsystems, and the like.

[0032] FIG. 2 is a partial perspective view of a polishing station 124 of FIG. 1 comprising the auto disc changer module 150. FIG. 3 is a top schematic view of the polishing station comprising the auto disk changer module 150 of FIG. 2. In one embodiment, as shown in FIG. 1, the auto disk changer module 150 comprises a
disk load/unload station 152 for unloading used conditioning disks from the pad conditioning assembly 140 and loading unused conditioning disks onto the pad conditioning assembly 140, one or more disk storage stations 154 for storing both used and unused conditioning disks, and a central robot 156 having a range of motion sufficient for transferring both used and unused conditioning disks between the disk load/unload station 152 and the one or more disk storage stations 154.

[0033] FIG. 4 is a side schematic view of a disk load/unload pedestal. In one embodiment, the disk load/unload station 152 comprises a disk load/unload pedestal 400. In one embodiment, the disk load/unload pedestal 400 may be coupled directly with the polishing module 106. In another embodiment, the disk load/unload pedestal 400 may be coupled with a separate plate coupled with the polishing module 106.

[0034] In one embodiment, the disk load/unload pedestal 400 comprises a pedestal body 402, a magnetic element 404 coupled with the pedestal body 402, and a lift mechanism 406 for raising and lowering the magnetic element 404. The magnetic element 404 uses magnetic force to detach the pad conditioning disk 148 from the conditioning head 142. In one embodiment, the magnetic element 404 is an electromagnet coupled with the lift mechanism 406 of the disk load/unload pedestal 400. The magnetic element 404 may be selectively energized by the power source 180 to create a bias force attracting the conditioning disk 148 to the pedestal body 402. As the magnetic force applied by the magnetic element 404 is easily regulated by the power source 180, the contact force between the conditioning disk 148 and the pedestal body 402 may be optimally tailored for specific routines. Moreover, as the attraction force between the conditioning disk 148 and the pedestal body 402 may be removed by interrupting power applied to the magnetic element 404, the conditioning disk 148 may be easily separated from the pedestal body 402. Optionally, the polarity of the magnetic force generated by the magnetic element 404 may be reversed to assist removing the conditioning disk 148 in instances where the conditioning disk 148 has become magnetized and/or contains permanent magnetic material. Alternatively, the magnetic element 404
may be a permanent magnet. It is contemplated that the magnetic element 404 may be disposed in other positions within or adjacent to the pedestal body 402.

[0035] In one embodiment, the lift mechanism 406 may be a passive z-axis lift mechanism. In one embodiment, the lift mechanism 406 comprises a motor coupled with a lead screw that moves a drive nut attached to the magnetic element 404. As the drive nut is urged vertically by the rotating lead screw, the magnetic element 404 moves either upward or downward. Alternatively, the lift mechanism 406 may be any form of a vertical actuator for controlling the position of the magnetic element 404. The pedestal body 402, the magnetic element 404, and the lift mechanism 406 may comprise process resistant materials such as ceramics, aluminum, steel, nickel, polymers, and the like that are process resistant and are generally free of contaminates such as copper.

[0035] With reference to FIG. 2, the auto disk changer module 150 further comprises one or more disk storage stations 154 for storing both used and unused conditioning disks. In one embodiment, the one or more disk storage stations 154 comprises a disk storage rack 208. The disk storage rack 208 may be coupled directly with the polishing module 106. In another embodiment, the disk storage rack 208 may be coupled with a separate plate coupled with the polishing module 106.

[0036] The disk storage rack 208 comprises a plurality of storage shelves 210 supported by a frame 220. Although in one aspect, FIG. 2 illustrates five storage shelves within the disk storage rack 208, it is contemplated that any number of storage shelves 210 may be used. Each storage shelf 210 comprises a conditioning disk support member 212 connected by brackets (not shown) to a frame 220. The brackets connect the edges of the conditioning disk support member 212 to the frame 220 and may be coupled with both the frame 220 and conditioning support member 212 using adhesives such as pressure sensitive adhesives, ceramic bonding, glue, and the like, or fasteners such as screws, bolts, clips, and the like that are process resistant and are free of contaminates such as copper. The frame 220, storage shelves 210, and brackets may comprise process resistant materials such as ceramics, aluminum, steel, nickel, polymers, and the like that are process
resistant and are generally free of contaminants such as copper. While the frame 220 and brackets may be separate items, it is contemplated that the brackets and conditioning disk support members 212 may be integral to the frame 220.

[0037] The storage shelves 210 are spaced vertically apart and parallel within the disk storage rack 208 to define a plurality of storage spaces. Each storage space is adapted to store at least one conditioning disk 148 therein supported by each conditioning disk support member 212. The storage shelves 210 above and below each conditioning disk 148 establish the upper and lower boundary of each storage space.

[0038] In one embodiment, as shown in FIG. 1, the auto disk changer module 150 further comprises a central robot 156 having a range of motion sufficient for transferring both used and unused conditioning disks between the disk load/unload station 152 and the one or more disk storage stations 154. The central robot 156 is adapted to access both the disk load/unload station 152 and the one or more disk storage stations 154. In one embodiment, the central robot 156 comprises a shuffling robot assembly 260 (see FIG. 2) generally comprising a shuffling robot body 262 coupled with an end effector assembly 264 (e.g., the single blade assembly). The shuffling robot assembly 260 may be a 2-axis robot. In one embodiment, the shuffling robot assembly 260 has rotational motion as shown by arrow 266. In one embodiment, the rotational motion may be provided by an actuator such as a rotary air cylinder or a motor. In one embodiment, the shuffling robot assembly 260 has vertical motion as shown by arrow 268. The shuffling robot assembly 260 may comprise a robot base 270 which couples the shuffling robot assembly 260 with the polishing module 106. In another embodiment, the robot base 270 may be coupled with a separate plate coupled with the polishing module 106.

[0039] In one embodiment, the shuffling robot body 262 comprises a tubular member. The shuffling robot body 262 may comprise process resistant materials such as ceramics, aluminum, steel, nickel, polymers, and the like that are process resistant and are generally free of contaminants such as copper.
[0040] In one embodiment, the end effector assembly 264 may be movably coupled with the shuffling robot assembly 260 such that the end effector assembly 264 may be rotated in either direction in relation to the shuffling robot assembly 260 about an axis perpendicular to the shuffling robot body 262 and extending through the end effector assembly 264. In one embodiment, the end effector assembly 264 comprises one or more blade assemblies which may contain one or more blades comprising a conditioning disk receiving surface adapted to retain a conditioning disk positioned on the blade (not shown) by use of various retaining means such as a suction mechanism or edge gripping members that hold the substrate in position on the robot blade. The edge gripping mechanism can be adapted to grab the edge of the conditioning disk at multiple points (e.g., 3 points) to hold and retain the conditioning disk.

[0041] In one embodiment, the blade may have two opposing conditioning disk supporting sides. For example, a used conditioning disk may be secured on one conditioning disk supporting side and an unused conditioning disk may be supported on the other conditioning disk supporting side. In one embodiment, the blade may have sensors (not shown) detecting the position of the substrate with respect to the blade as the end effector assembly 264 is positioned.

[0042] FIG. 3 is a top schematic view of the auto disk changer module of FIG. 2. In operation, with reference to FIG. 2 and FIG. 3, the pad conditioning assembly 140 deposits a used conditioning disk 148 on the disk load/unload station 152. In another embodiment, where the disk load/unload station 152 comprises a disk load/unload pedestal, the used conditioning disk may be placed directly on the disk load/unload pedestal prior to be retrieved by the central robot 156. In one embodiment, where the conditioning disk 148 is magnetically coupled with the pad conditioning assembly 140, the magnetic element 404 may be selectively energized by the power source 180 to create a bias force attracting the conditioning disk 148 to the pedestal body 402. The conditioning disk 148 may then be retrieved by the central robot 156 from the pedestal body 402. In another embodiment, the end effector assembly 264 of the central robot 156 is positioned over the magnetic element 404 and the magnetic element 404 is selectively energized by the power
source 180 removing the conditioning disk 148 from the pad conditioning assembly 140 and attracting the conditioning disk 148 onto the end effector assembly 264 of the central robot 156.

[0043] After coupling the conditioning disk 148 with the end effector assembly 264 of the central robot 156, the central robot 156 transfers the used conditioning disk to the one or more disk storage stations 154 where the used conditioning disk 148 is deposited on an empty storage shelf. The central robot 156 then retrieves an unused conditioning disk from the one or more disk storage stations 154 and transfers the unused conditioning disk 148 to the disk load/unload station 152. The unused conditioning disk 148 may then be coupled with the pad conditioning assembly 140 and the polishing and conditioning process may continue.

[0044] In one embodiment, where the end effector assembly 264 comprises a blade having two conditioning disk supporting sides, an unused conditioning disk may be retrieved from the one or more disk storage stations 154 and positioned on one conditioning disk supporting side and transported to the disk load/unload station 152. At the disk load/unload station 152 the blade may rotate such that the empty disk supporting side can retrieve the used conditioning disk. After securing the used conditioning disk, the blade may rotate such that the unused conditioning disk is facing the conditioning head 142 of the pad conditioning assembly 140 where the unused conditioning disk may be retrieved from the blade.

[0045] FIG. 5 is a top schematic view of another embodiment of an auto disk changer module 150. In another embodiment, as depicted in FIG. 5, the auto disk changer module 150 further comprises an additional shuffling robot 502 positioned adjacent to the central robot 156 and the one or more disk storage stations 154. The additional shuffling robot 502 may be adapted to retrieve conditioning disks from and deliver conditioning disks to the central robot 156. The additional shuffling robot 502 may also be adapted to transfer conditioning disks 148 into and out of the one or more disk storage stations 154. In one embodiment, the central robot 156 transfers a used disk to the additional shuffling robot 502. The additional shuffling robot positions the used disk in the one or more disk storage stations 154 and retrieves an unused conditioning disk from the one or more disk storage stations.
154. The central robot 156 retrieves and transfers the unused conditioning disk to the pad conditioning assembly 140. Advantageously, the central robot 156 deposits the used conditioning disk and retrieves the unused conditioning disk from the same position.

[0046] FIG. 6 is a top schematic view of another embodiment of an auto disk changer module 150. The auto disk changer module 150 comprises a used disk holder 602 and an unused disk holder 604. It should be understood that the positions of the used disk holder 602 and the unused disk holder 604 may be reversed. The pad conditioning assembly 140 discards a used disk in the used disk holder 602 and retrieves an unused disk from the unused disk holder 604. In one embodiment, the used disk holder 602 and the unused disk holder 604 may be adapted to hold a vertical stack of conditioning disks. In one embodiment, the conditioning disk 148 may be coupled with and decoupled from the pad conditioning assembly 140 by actuators located on the pad conditioning assembly 140 or actuators located on the disk holders 602, 604. In another embodiment, coupling and decoupling of the conditioning disk from the pad conditioning assembly 140 may be accomplished by passive mechanisms taking advantage of the existing up and down motion of the pad conditioning assembly 140. The used disk holder 602 and the unused disk holder 604 advantageously provide a reduced system footprint and reduced system complexity.

[0047] FIG. 7 is a top schematic view of another polishing station 124 of a chemical mechanical polishing system and FIG. 8 is a side view of a pad conditioning assembly 140 of FIG. 7. In one embodiment, the auto disk change may be accomplished by carrying multiple conditioning disks 700a-c on the pad conditioning assembly 140. In the exemplary embodiment shown in FIG. 7 and FIG. 8, three conditioning disks 700a-c are shown. Although three conditioning disks 700a-c are shown, it should be understood that any number of conditioning disks may be carried on the pad conditioning assembly 140.

[0048] In this embodiment, the pad conditioning head 142 may index between conditioning disks to extend the usable life of each conditioning disk. For example, as shown in FIG. 8, the spare conditioning disks 700b and 700a (not visible in this
view) may be raised above the platen and not used until the active conditioning disk 700b which engages the polishing surface 130 during conditioning reaches the end of its usable life. Alternatively, the multiple conditioning disks 700a-c may be cycled in and out at high frequency to average out variations in conditioning disk quality. In another embodiment, the conditioning disks may be coupled with a cylinder which is coupled with conditioning head 142. As the cylinder rotates, a different conditioning disk is moved into the active position facing the polishing surface 130.

[0049] Although the embodiments described herein generally refer to conditioning disks, it should be understood that the embodiments described herein may be used with conditioning members of any shape and/or size.

[0050] While the foregoing is directed to embodiments described herein, 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.
Claims:

1. An apparatus for replacing a polishing pad conditioning disk in a chemical mechanical polishing system, comprising:
   a disk load/unload station for unloading used conditioning disks from a pad conditioning assembly and loading unused conditioning disks onto the pad conditioning assembly;
   one or more disk storage stations for storing both used and unused conditioning disks; and
   a central robot having a range of motion sufficient for transferring both used and unused conditioning disks between the disk load/unload station and the one or more disk storage stations.

2. The apparatus of claim 1, wherein the disk load/unload station comprises:
   a pedestal body;
   a magnetic element coupled with the pedestal body; and
   a lift mechanism for raising and lowering the magnetic element.

3. The apparatus of claim 2, wherein the one or more disk storage stations comprises:
   a frame; and
   a plurality of storage shelves supported by the frame, wherein the plurality of storage shelves are spaced vertically apart and parallel to define a plurality of conditioning disk storage spaces supported by the frame.

4. The apparatus of claim 3, wherein the central robot comprises:
   a shuffling robot body; and
   an end effector assembly coupled with the shuffling robot body.

5. The apparatus of claim 4, wherein the end effector assembly comprises one or more blades comprising a conditioning disk receiving surface adapted to retain a conditioning disk positioned on the blade.
6. The apparatus of claim 5, wherein the one or more blades have two opposing conditioning disk supporting sides.

7. The apparatus of claim 1, further comprising a shuffling robot positioned adjacent to the central robot and the one or more disk storage stations, wherein the shuffling robot has a range of motion sufficient to retrieve conditioning disks from and deliver conditioning disks to the one or more disk storage stations.

8. The apparatus of claim 1, wherein the central robot is positioned in between the disk load/unload station and the one or more disk storage stations.

9. A chemical mechanical polishing system, comprising:
   a platen assembly;
   a polishing surface supported on the platen assembly;
   one or more polishing heads on which substrates are retained while polishing;
   a pad conditioning assembly for dressing the polishing surface by removing polishing debris and opening the pores of the polishing surface; and
   an auto disk changer module for replacing a polishing pad conditioning disk.

10. The system of claim 9, wherein the one or more polishing heads are coupled to an overhead circular track that allows the one or more polishing heads to be selectively positioned over the polishing surface.

11. The system of claim 9, wherein the auto disk changer module, comprises:
    a disk load/unload station for unloading used conditioning disks from a pad conditioning assembly and loading unused conditioning disks onto the pad conditioning assembly;
    one or more disk storage stations for storing both used and unused conditioning disks; and
a central robot having a range of motion sufficient for transferring both used and unused conditioning disks between the disk load/unload station and the one or more disk storage stations.

12. A method for replacing a polishing pad conditioning disk in a chemical mechanical polishing system, comprising:
   unloading a used conditioning disk from a pad conditioning assembly at a disk load/unload station;
   retrieving the used conditioning disk with a central robot;
   transferring the used conditioning disk using the central robot from the disk load/unload station to one or more disk storage stations;
   unloading the used conditioning disk;
   retrieving an unused conditioning disk from the one or more disk storage stations;
   transferring the unused conditioning disk using the central robot to the load/unload station; and
   loading the unused conditioning disk onto the pad conditioning assembly.

13. The method of claim 12, wherein unloading the used conditioning disk from a pad conditioning assembly comprises selectively energizing a magnetic element to create a bias force to remove the conditioning disk from the pad conditioning assembly.

14. The method of claim 12, wherein the unloading the used conditioning disk, comprises transferring the used conditioning disk to a shuffling robot, wherein the shuffling robot positions the used disk in the one or more disk storage stations.

15. The method of claim 13, wherein retrieving an unused conditioning disk from the one or more disk storage stations comprises retrieving an unused conditioning disk from the one or more disk storage stations using the shuffling robot.