METHODS AND APPARATUS USING ENERGIZED FLUIDS TO CLEAN CHEMICAL MECHANICAL PLANARIZATION POLISHING PADS

Applicant: APPLIED MATERIALS, INC., Santa Clara, CA (US)

Inventors: Jianshe Tang, San Jose, CA (US); Thomas H. Osterheld, Mountain View, CA (US); Fred C. Redeker, Fremont, CA (US); Gregory E. Menk, Pleasanton, CA (US)

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ABSTRACT
Methods adapted to clean a chemical mechanical polishing (CMP) pad are disclosed. The methods include positioning an energized fluid delivery assembly over a CMP polishing pad; rotating the polishing pad on a platen; energizing a fluid within the energized fluid delivery assembly; applying the energized fluid to the polishing pad to dislodge slurry residue and debris; and removing the dislodged slurry residue and debris using a vacuum suction unit. Systems and apparatus for carrying out the methods are provided, as are numerous additional aspects.
FIG. 5

502  POSITION ENERGIZED FLUID DELIVERY ASSEMBLY ABOVE CMP POLISHING PAD

504  ROTATE CMP PAD AND ENERGIZE FLUID

506  APPLY ENERGIZED FLUID TO CMP PAD WHILE MONITORING PAD

508  COMPLETE CLEANING BASED ON STATUS OF CMP PAD
METHODS AND APPARATUS USING ENERGIZED FLUIDS TO CLEAN CHEMICAL MECHANICAL PLANARIZATION POLISHING PADS

FIELD

[0001] The present invention generally relates to electronic device manufacturing, and more particularly is directed to using fluids to clean chemical mechanical planarization (CMP) polishing pads.

BACKGROUND

[0002] The electronics industry currently spends in excess of one billion U.S. Dollars each year manufacturing silicon substrates that must exhibit very flat and smooth surfaces. Known techniques to manufacture smooth and even-surfaced silicon substrates are plentiful. The most common of these involves the process known as chemical mechanical polishing (CMP) which includes the use of a polishing pad in combination with abrasive slurry. Of central importance in CMP processes is the attainment of high performance levels in aspects such as uniformity of polished substrate, smoothness of the IC circuitry, removal rate for productivity, longevity of consumables for CMP economics, etc. Chemical mechanical polishing (sometimes known in the art as chemical mechanical planarization), or CMP, is thus a well-known process used in the fabrication of electronic devices. CMP combines mechanical polishing (using, for example, abrasive slurries) with selective chemical reactions to increase the mechanical removal rate of material. The chemical reactions particularly provide greater material removal selectivity than mechanical polishing alone.

[0003] CMP is commonly used to flatten the surface of a substrate after etch and/or deposition steps, generally to such a degree that subsequent photolithography steps have a sufficient focus margin. In general, CMP is performed by using a polishing pad in combination with a slurry of water, abrasives, and reactive chemicals for the desired chemical reaction or reactions. The polishing pad is caused to be pressed against the substrate surface and relative motion between the substrate and the pad is imparted (that is, by moving one or both of the substrate and the pad).

[0004] The polishing pad is conventionally a porous pliable material. Polyurethane foam is particularly common for use as a polishing pad. Surface asperities of the polishing pad are critical to the polishing process because they provide the mechanical polishing action. However, as the pad is used for polishing, it tends to become smoother as the asperities are rubbed away and/or as slurry residues build up in the pores. As a result, the polishing process is degraded. It is therefore conventionally known to condition the polishing pad to roughen the surface and increase the open porosity of the foam.

[0005] Conventional conditioning methods however typically wear the polishing pad such that a given pad can only be conditioned a finite number of times before it must be discarded. Thus, what is needed are systems, methods, and apparatus that allow the useful life of CMP polishing pads to be extended, but still effectively remove slurry and debris from the pores and grooves of the pad without unnecessarily wearing the pad.

SUMMARY

[0006] Inventive embodiments of methods and apparatus are provided for cleaning slurry and debris from CMP polishing pads by applying energized fluids to the polishing pads. Embodiments of the present invention use energized fluid (e.g., liquids and gases) to clean off slurry residues and pad debris between substrate polishing or during wafer polishing. During an energized fluid cleaning cycle, as the polishing pad is sprayed or otherwise applied with energized liquids or gases that loosen and dislodge slurry residue and pad debris, a vacuum pump is used to remove the dislodged material. In some embodiments, a scraper, beater, and/or a rotating bristle brush may selectively, continuously, or intermittently contact the polishing pad to further help loosen and dislodge residue and debris. In some embodiments, instead of merely pressurizing a fluid, the energized fluid can be acoustically energized (e.g., via acoustic cavitation), pneumatically assisted (e.g., using a liquid mixed with a pressurized gas), and/or thermally state changed (e.g., liquid heated to gas). Other methods and combinations of energizing fluids can be used.

[0007] In some embodiments, a method for cleaning a chemical mechanical polishing (CMP) pad is provided. The method includes positioning an energized fluid delivery assembly over a CMP polishing pad; rotating the polishing pad on a platen; energizing a fluid within the energized fluid delivery assembly; applying the energized fluid to the polishing pad to dislodge slurry residue and debris; and removing the dislodged slurry residue and debris using a vacuum suction unit.

[0008] In some other embodiments, a system for cleaning a chemical mechanical polishing (CMP) pad is embodiment. The system includes a processor; and a memory storing instructions executable by the processor, the instructions operative to: position an energized fluid delivery assembly over a CMP polishing pad; rotate the polishing pad on a platen; energize a fluid within the energized fluid delivery assembly; apply the energized fluid to the polishing pad to dislodge slurry residue and debris; and remove the dislodged slurry residue and debris using a vacuum suction unit.

[0009] In yet other embodiments, an apparatus for cleaning a chemical mechanical polishing (CMP) pad is provided. The apparatus includes an energized fluid delivery assembly configured to energize a fluid and apply the energized fluid to a CMP polishing pad to dislodge slurry residue and debris from the polishing pad; and a vacuum suction unit configured to remove the dislodged slurry residue and debris.

[0010] In still yet other embodiments, a system for cleaning a chemical mechanical polishing (CMP) pad is provided. The system includes a polishing pad configured to be rotated on a platen; a polishing head configured to hold a substrate against the polishing pad; and an energized fluid delivery assembly configured to apply an energized fluid to the polishing pad to dislodge slurry residue and debris from the polishing pad.

[0011] Numerous other aspects are provided. Other features and aspects of the present invention will become more fully apparent from the following detailed description, the appended claims and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 illustrates a schematic side-view drawing depicting an example of a CMP system according to embodiments.
[0013] FIGS. 2A to 2C illustrate top, side, and front views respectively of an energized fluid cleaning assembly and an example of an energized fluid cleaning assembly according to a first embodiment.

[0014] FIGS. 3A and 3B illustrate top and side views respectively of a CMP polishing pad and an example of an energized fluid cleaning assembly according to a second embodiment.

[0015] FIGS. 4A to 4C illustrate top, side, and front views respectively of a CMP polishing pad and an example of an energized fluid cleaning assembly according to a third embodiment.

[0016] FIG. 5 illustrates a flowchart depicting an example method of cleaning a CMP polishing pad using energized fluid according to some embodiments.

DETAILED DESCRIPTION

[0017] Embodiments of the present invention provide improved systems, methods and apparatus configured to clean slurry and debris from CMP polishing pads by applying energized fluids to the polishing pads. During CMP, slurries and pad debris are accumulated and become trapped within pad grooves and pores, which can cause scratches on the substrate being polished. Current state-of-the-art technology uses a high-pressure (e.g., ~40 PSI) de-ionized water (DIW) rinse and/or vacuum to pick up such residues from the pad. However, the high-pressure DIW rinse and vacuum have been shown not to be sufficient to dislodge slurry/debris residues from the pad grooves and pores. Therefore, conventional methods of using high-pressure DIW rinse and vacuum are not sufficient for pad cleaning.

[0018] One or more embodiments of the present invention use energized fluid (e.g., liquids and gases) to clean off slurry residues and pad debris between wafer polishing or during wafer polishing. During an energized fluid cleaning cycle, as the polishing pad is sprayed or otherwise applied with energized liquids or gases that loosen and dislodge slurry residue and pad debris, a vacuum pump is used to remove the dislodged material. In some embodiments, a scraper, brush, etc. or rotating brush may selectively, continuously, or intermittently contact the polishing pad to further help loosen and dislodge residue and debris. In some embodiments, instead of merely pressurizing a fluid, the energized fluid can be acoustically energized (e.g., via acoustic cavitation), pneumatically assisted (e.g., using a liquid mixed with a pressurized gas), and/or thermally state changed (e.g., liquid heated to gas). Other methods and combinations of energizing fluids can be used. In some embodiments, the present invention can be used for pad cleaning, pad conditioning, and brush break-in.

[0019] Turning to FIG. 1, a side view of an example chemical-mechanical planarization (CMP) system 100 for polishing substrates is shown. The system 100 includes a polishing head assembly 102 supported by an polishing head arm 104 operative to position the polishing head assembly 102 over a polishing pad 106 supported by and rotated on a platen 108. The platen 108 is driven to rotate by a motor 110. In operation, the polishing head assembly 102 is operative to securely hold a substrate, to rotate the substrate, and to press the substrate against the rotating polishing pad 106 during CMP processing. In other words, as the polishing pad 106 is rotated on the platen 108, the head 102 rotates and pushes the substrate down against the polishing pad 106.

[0020] The system 100 also includes an energized fluid delivery assembly 112 supported by fluid delivery arm 114. The fluid delivery arm also supports a vacuum suction unit 116 operative to remove residue and debris dislodged by the application of the energized fluid to the CMP polishing pad 106.

[0021] Each of the components can be coupled to, and operated by, a controller 118 (e.g., a processor, a programmable logic controller, an embedded controller, etc.) operative to execute instructions (e.g., software, programs, commands, signals, etc.) to perform the methods of the present invention, and in particular, the methods described below with respect to the flowchart in FIG. 5.

[0022] As indicated above, the energized fluid can be acoustically energized. Ultrasonically or megasonically energized fluid (e.g., fluid that experiences acoustic cavitation) can dislodge residues from large areas like polishing pad grooves and also from smaller areas like polishing pad pores. This capability to dislodge particles from both larger and smaller areas provides for a higher cleaning efficiency of the polishing pad as compared to conventional methods.

[0023] FIGS. 2A through 2C depict top, side and front views respectively of an energized fluid delivery assembly 112 (FIG. 1) that includes an acoustically energized fluid delivery unit 212 that is adapted to delivery acoustically energized fluid 214 to the polishing pad 106 while vacuum suction unit 116 removes dislodged residue and debris. In some embodiments, the acoustically energized fluid delivery unit 212 can include a piezoelectric transducer (PZT) operating in the frequency range from the lower ultrasonic range (approximately 20 kHz) to the upper megasonic range (approximately 2 MHz). Other frequency ranges can be used. The shape of a suitable acoustic energy source generator (e.g., a PZT) can be rectangular with dimensions in the range of approximately 5 mm x 50 mm to approximately 15 mm x 1500 mm. Other sized PZTs can be used. For example, with a polishing pad radius of 15 inches, a PZT with a length of 15 inches may be used. Likewise, the vacuum suction unit 116 can be the same length.

[0024] In some embodiments, shorter length PZTs can be used in the acoustically energized fluid delivery unit 212 where the acoustically energized fluid delivery unit 212 is adapted to be swept from the center of the pad 106 to the edge of the pad 106. In such embodiments, the fluid delivery arm 114 (FIG. 1), can be used to sweep the acoustically energized fluid delivery unit 212 across the pad 106 radially. Alternatively, a separate gantry can be used to sweep the acoustically energized fluid delivery unit 212 back and forth radially over the pad 106.

[0025] In some embodiments, the acoustically energized fluid delivery unit 212 can include a housing with an input channel to receive fluid, a PZT held within the housing to apply energy to the received fluid, and a slot or plurality of nozzles along the bottom length of the housing aimed at the polishing pad 106 to distribute the energized fluid 214 across the polishing pad 106. In some embodiments, the housing or individual nozzles can be configured to rock back and forth as energized fluid 214 is being dispensed to further enhance the loosening action of the energized fluid 214 by continually altering the angle of impact of the energized fluid 214 on the pad 106.

[0026] As indicated by the ‘H’ dimension labeled in FIGS. 2A and 2C, the acoustically energized fluid delivery unit 212 can be disposed from approximately 4 mm to approximately
10 mm above the polishing pad 106 during application of the acoustically energized fluid 214. Likewise the vacuum suction unit can be similarly disposed from approximately 4 mm to approximately 10 mm above the polishing pad 106 during application of the acoustically energized fluid 214.

[0027] In some embodiments, the fluid that is energized can be deionized water (DIW) and/or cleaning chemistry. The temperature of the fluid can be from 20 C. to 90 C. Other temperatures can be used. The flow rate of the energized fluid 214 can be in the range of approximately 100 ml/min to approximately 10 L/min. Other flow rates can be used. In some embodiments, the cleaning chemistry can be, for example, diluted potassium hydroxide (KOH) when using, for example, SemiSperse® SS12 slurry manufactured by Cabot Microelectronics Corporation of Aurora, Ill.

[0028] In some embodiments, a scraper, beater, and/or a rotating bristle brush may selectively, continuously, or intermittently contact the polishing pad 106 to further help loosen and dislodge residue and debris. The use of a scraper, beater, and/or a rotating bristle brush may be selectively applied by the controller 118. An optical sensor can be used to inspect the pad 106 and provide information to the controller 118 as to the status of the pad 106. Based on the status of the pad 106, the controller 118 can determine if the pad should continue to be treated with energized fluid, if higher energy should be applied to the fluid (e.g., heat, pressure, acoustic energy, etc.), or if the pad should receive contact from a scraper, beater, and/or a rotating bristle brush.

[0029] As indicated above, the energized fluid can alternatively be energized using pressurized gas. As with acoustically energized fluid, pressurized gas assisted liquid spray jets can be used to effectively dislodge residue and debris from large areas like polishing pad grooves and also from smaller areas like polishing pad pores. As noted, this capability provides for high cleaning efficiency of the polishing pad as compared to conventional pad cleaning methods. The pressurized gas assisted spray removes particles via fluid droplet momentum transfer. Because this method has a lower fluid flow rate, not only is DIW conserved, the amount of splash is drastically reduced and therefore, there is substantially less slurry residue build up within the system 100.

[0030] FIGS. 3A and 3B depict top and side views respectively of an energized fluid delivery assembly 112 (FIG. 1) that includes an energized gas pressurized fluid delivery unit 312 that is adapted to delivery pressurized gas energized fluid 314 to the polishing pad 106 while vacuum suction unit 116 removes dislodged residue and debris. In some embodiments, the pressurized gas energized fluid delivery unit 312 can include a pressurized gas supply such as filtered air or nitrogen (N₂). The mixing chamber within the pressurized gas energized fluid delivery unit 312 can be rectangular with dimensions in the range of approximately 5 mm x 50 mm to approximately 15 mm x 1500 mm. Other sized mixing chambers can be used. For example, with a polishing pad radius of 15 inches, a mixing chamber with a length of 15 inches may be used. Likewise, the vacuum suction unit 116 can be the same length.

[0031] In some embodiments, shorter length mixing chambers can be used in the pressurized gas energized fluid delivery unit 312 where the delivery unit 312 is adapted to be swept from the center of the pad 106 to the edge of the pad 106 as indicated by the double ended arrow in FIG. 3A. In such embodiments, the fluid delivery arm 114 (FIG. 1), can be used to sweep the pressurized gas energized fluid delivery unit 312 across the pad 106 radially. Alternatively, a separate gantry can be used to sweep the pressurized gas energized fluid delivery unit 312 back and forth radially over the pad 106.

[0032] In some embodiments, the pressurized gas energized fluid delivery unit 312 can include a housing with a liquid input channel to receive the liquid and a gas input channel to receive the pressurized gas. The housing also includes the mixing chamber to apply the pressurized gas to the liquid and a slot or plurality of nozzles along the bottom length of the housing aimed at the polishing pad 106 to distribute the energized fluid 314 across the polishing pad 106. In some embodiments, the housing or individual nozzles can be configured to rock back and forth as energized fluid 314 is being dispersed to further enhance the loosening action of the energized fluid 314 by continually altering the angle of impact of the energized fluid 314 on the pad 106.

[0033] As indicated by the ‘H’ dimension labeled in FIG. 3B, the pressurized gas energized fluid delivery unit 312 can be disposed from approximately 10 mm to approximately 100 mm above the polishing pad 106 during application of the pressurized gas energized fluid 314. The vacuum suction unit can be disposed from approximately 4 mm to approximately 10 mm above the polishing pad 106 during application of the pressurized gas energized fluid 314.

[0034] In some embodiments, the fluid that is energized can be deionized water (DIW) and/or cleaning chemistry. The temperature of the fluid can be from 20 C. to 90 C. Other temperatures can be used. In some embodiments, the air pressure applied to energize the fluid can be in the range from approximately 40 PSI to approximately 140 PSI. Other pressures can be used. The liquid flow rate can be in the range from approximately 100 ml/min to approximately 2 L/min. Other flow rates can be used. The droplet speed can be in the range from approximately 100 m/s to approximately 300 m/s. Other droplet speeds can be used. In some embodiments, the cleaning chemistry can be, for example, diluted potassium hydroxide (KOH) when using, for example, SemiSperse® SS12 slurry manufactured by Cabot Microelectronics Corporation of Aurora, Ill.

[0035] In some embodiments, a scraper, beater, and/or a rotating bristle brush may selectively, continuously, or intermittently contact the polishing pad 106 to further help loosen and dislodge residue and debris. The use of a scraper, beater, and/or a rotating bristle brush may be selectively applied by the controller 118. An optical sensor can be used to inspect the pad 106 and provide information to the controller 118 as to the status of the pad 106. Based on the status of the pad 106, the controller 118 can determine if the pad should continue to be treated with energized fluid, if higher energy should be applied to the fluid (e.g., heat, pressure, acoustic energy, etc.), or if the pad should receive contact from a scraper, beater, and/or a rotating bristle brush.

[0036] As indicated above, the energized fluid can alternatively be thermally energized to change state. As with acoustically and pressurized gas energized fluid, thermally energized liquid forced to change state (e.g., using an ultrapure DIW to steam generator) can be used to effectively dislodge residue and debris from large areas like polishing pad grooves and also from smaller areas like polishing pad pores. As noted, this capability provides for high cleaning efficiency of the polishing pad as compared to conventional pad cleaning methods. The thermally energized gas removes particles via heat transfer. Because this method has a lower fluid flow rate, not only is DIW conserved, the amount of...
splash is drastically reduced and therefore, there is substantially less slurry residue build up within the system 100.

[0037] FIGS. 4A through 4C depict top, side, and front views respectively of an energized fluid delivery assembly 112 (FIG. 1) that includes a thermally energized fluid delivery unit 412 that is adapted to deliver thermally energized fluid 414 to the polishing pad 106 while vacuum suction unit 116 removes dislodged residue and debris. In some embodiments, the thermally energized fluid delivery unit 412 can include a heater to vaporize cleaning fluid. The vaporizing chamber within the thermally energized fluid delivery unit 412 can be rectangular with dimensions in the range of approximately 5 mmx50 mm to approximately 15 mmx1500 mm. Other sized vaporizing chambers can be used. For example, with a polishing pad radius of 15 inches, a vaporizing chamber with a length of 15 inches may be used. Likewise, the vacuum suction unit 116 can be the same length.

[0038] In some embodiments, shorter length vaporizing chambers can be used in the thermally energized fluid delivery unit 412 where the delivery unit 412 is adapted to be swept from the center of the pad 106 to the edge of the pad 106. In such embodiments, the fluid delivery arm 114 (FIG. 1), can be used to sweep the thermally energized fluid delivery unit 412 across the pad 106 radially. Alternatively, a separate gantry can be used to sweep the thermally energized fluid delivery unit 412 back and forth radially over the pad 106.

[0039] In some embodiments, the thermally energized fluid delivery unit 412 can include a housing with a liquid input channel to receive the liquid. The housing can hold a heating element that receives electrical energy to vaporize the liquid. The housing also includes the vaporizing chamber to apply the thermal energy to the liquid and a slot or plurality of nozzles along the bottom length of the housing aimed at the polishing pad 106 to distribute the energized fluid 414 across the polishing pad 106. In some embodiments, the housing or individual nozzles can be configured to rock back and forth as energized fluid 414 is being dispersed to further enhance the loosening action of the energized fluid 414 by continually altering the angle of contact of the energized fluid 414 on the pad 106.

[0040] As indicated by the ‘H’ dimension labeled in FIGS. 4B and 4C, the thermally energized fluid delivery unit 412 can be disposed from approximately 4 mm to approximately 10 mm above the polishing pad 106 during application of the thermally energized fluid 414. The vacuum suction unit can be similarly disposed from approximately 4 mm to approximately 10 mm above the polishing pad 106 during application of the pressurized gas energized fluid 414.

[0041] In some embodiments, the fluid that is energized can be deionized water (DIW) and/or cleaning chemistry. The temperature of the fluid can be from 20 C. to 90 C. Other temperatures can be used. In some embodiments, the heat energy applied to energize the fluid can be in the range from approximately 2 Kcal (2 Cal) to approximately 2000 Kcal (2000 Cal). Other amounts of thermal energy can be used. The liquid flow rate can be in the range from approximately 100 ml/min to approximately 10 L/min. Other flow rates can be used. In some embodiments, the cleaning chemistry can be, for example, diluted potassium hydroxide (KOH) when using, for example, SemiSpere® SS12 slurry manufactured by Cabot Microelectronics Corporation of Aurora, Ill.

[0042] In some embodiments, a scraper, beater, and/or a rotating bristle brush may selectively, continuously, or intermittently contact the polishing pad 106 to further help loosen and dislodge residue and debris. The use of a scraper, beater, and/or rotating bristle brush may be selectively applied by the controller 118. An optical sensor can be used to inspect the pad 106 and provide information to the controller 118 as to the status of the pad 106. Based on the status of the pad 106, the controller 118 can determine if the pad should continue to be treated with energized fluid, if higher energy should be applied to the fluid (e.g., heat, pressure, acoustic energy, etc.), or of the pad should receive contact from a scraper, beater, and/or a rotating bristle brush.

[0043] Turning now to FIG. 5, a flowchart depicting an example method 500 of cleaning a CMP polishing pad is provided. Note that the steps listed can be implemented using the system 100 either manually by an operator or automatically by the controller 118 executing instructions or a program. In some embodiments, some steps may be performed manually while others are performed automatically. Also note that while four steps are listed to illustrate the method 500, other sub-steps and compound or super-steps can be included to increase or decrease the number of steps.

[0044] After CMP processing has been performed on one or more substrates, an energized fluid delivery assembly 112 is positioned above the CMP polishing pad 502. In some embodiments, the energized fluid delivery assembly 112 may be positioned over the pad 106 while CMP processing is performed. In some embodiments, the method 500 may be performed while CMP processing is being performed.

[0045] With the energized fluid delivery assembly 112 and the vacuum suction unit 116 in place, the CMP polishing pad 106 is rotated and the fluid in the energized fluid delivery assembly 112 is energized 504. In some embodiments, energizing the fluid can include applying acoustic energy, applying pressurized gas, applying thermal energy to change a liquid to a gas, or any combination of these methods.

[0046] The energized fluid is applied to the polishing pad 106 while the pad 106 is monitored 506. The energized fluid can be applied directly to the pad 106 and in some embodiments, the energized fluid can be sprayed at the pad 106 from continuously changing angles by pivoting the energized fluid delivery assembly 112 or its output ports (e.g., slot or nozzles). The energized fluid delivery assembly 112 can also be oscillated in a radial direction relative to the pad 106 to cover the full radius to the pad 106.

[0047] In some embodiments, the energized fluid can be simply applied for a fixed amount of time or a fixed amount of energized fluid can be applied. In some embodiments, an optical sensor can be used to monitor the pad 106. In some embodiments, the vacuum suction unit 116 can include one or more sensors to determine if anything more than energized fluid is being removed from the pad 106 and thus, that the pad 106 is clean. Thus, cleaning completion can be determined based upon the pad 106 receiving a predefined amount of energized fluid, based on a predefined amount of time passing, or based upon feedback from one or more sensors providing status of the pad 508.

[0048] Accordingly, while the present invention has been disclosed in connection with the preferred embodiments thereof, it should be understood that other embodiments may fall within the spirit and scope of the invention, as explained by the following claims.

The invention claimed is:

1. A chemical mechanical polishing (CMP) system comprising:
a polishing pad configured to be rotated on a platen; a polishing head configured to hold a substrate against the polishing pad; and an energized fluid delivery assembly configured to apply an energized fluid to the polishing pad to dislodge slurry residue and debris from the polishing pad.

2. The CMP system of claim 1 wherein the energized fluid delivery assembly includes an acoustically energized fluid delivery unit configured to impart acoustic energy to a fluid and to direct the energized fluid toward the polishing pad.

3. The CMP system of claim 1 wherein the energized fluid delivery assembly includes a pressurized gas energized fluid delivery unit configured to impart energy in the form of pressurized gas to a liquid and to direct the energized fluid toward the polishing pad.

4. The CMP system of claim 1 wherein the energized fluid delivery assembly includes a thermally energized fluid delivery unit configured to impart thermal energy to a liquid sufficient to cause the liquid to change state to a gas and to direct the energized fluid toward the polishing pad.

5. The CMP system of claim 1 further including a vacuum suction unit configured to remove slurry residue and debris dislodged by application of the energized fluid to the polishing pad.

6. The CMP system of claim 1 further including a controller operative to monitor the polishing pad to determine if the polishing pad has been cleaned.

7. The CMP system of claim 1 wherein the polishing pad is configured to be cleaned when CMP processing is not being performed.

8. An apparatus for cleaning a chemical mechanical polishing (CMP) polishing pad, the apparatus comprising: an energized fluid delivery assembly configured to energize a fluid and apply the energized fluid to a CMP polishing pad to dislodge slurry residue and debris from the polishing pad; and a vacuum suction unit configured to remove the dislodged slurry residue and debris.

9. The apparatus of claim 8 wherein the energized fluid delivery assembly includes an acoustically energized fluid delivery unit configured to impart acoustic energy to a fluid and to direct the energized fluid toward the polishing pad.

10. The apparatus of claim 8 wherein the energized fluid delivery assembly includes a pressurized gas energized fluid delivery unit configured to impart energy in the form of pressurized gas to a liquid and to direct the energized fluid toward the polishing pad.

11. The apparatus of claim 8 wherein the energized fluid delivery assembly includes a thermally energized fluid delivery unit configured to impart thermal energy to a liquid sufficient to cause the liquid to change state to a gas and to direct the energized fluid toward the polishing pad.

12. The apparatus of claim 8 further including a controller operative to monitor the polishing pad to determine if the polishing pad has been cleaned.

13. The apparatus of claim 8 wherein the apparatus is configured to clean the polishing pad when CMP processing is not being performed with the polishing pad.

14. A method of cleaning a chemical mechanical polishing (CMP) pad, the method comprising: positioning an energized fluid delivery assembly over a CMP polishing pad; rotating the polishing pad on a platen; energizing a fluid within the energized fluid delivery assembly; applying the energized fluid to the polishing pad to dislodge slurry residue and debris; and removing the energized fluid using a vacuum suction unit.

15. The method of claim 14 wherein energizing a fluid within the energized fluid delivery assembly includes energizing the fluid within an acoustically energized fluid delivery unit configured to impart acoustic energy to the fluid.

16. The method of claim 14 wherein energizing a fluid within the energized fluid delivery assembly includes energizing the fluid within a pressurized gas energized fluid delivery unit configured to impart energy in the form of pressurized gas to a liquid.

17. The method of claim 14 wherein energizing a fluid within the energized fluid delivery assembly includes energizing a fluid within a thermally energized fluid delivery unit configured to impart thermal energy to a liquid sufficient to cause the liquid to change state to a gas.

18. The method of claim 14 further including monitoring the polishing pad to determine if the polishing pad has been cleaned.

19. The method of claim 14 wherein applying the energized fluid to the polishing pad is performed when CMP processing is not being performed.

20. A system comprising: a processor; and a memory storing instructions executable by the processor, the instructions operative to: position an energized fluid delivery assembly over a CMP polishing pad; rotate the polishing pad on a platen; energize a fluid within the energized fluid delivery assembly; apply the energized fluid to the polishing pad to dislodge slurry residue and debris; and remove the dislodged slurry residue and debris using a vacuum suction unit.