A chemical mechanical polish system includes a polishing pad, a platen supporting and rotating the polishing pad, a top slurry dispenser placed over a polishing pad, a bottom slurry dispenser placed through an opening in the polishing pad, and a duct connected to the bottom slurry dispenser, the duct extending toward the bottom of the polishing pad.
FIG. 1 (PRIOR ART)
CHEMICAL MECHANICAL POLISH SYSTEM HAVING MULTIPLE SLURRY-DISPENSING SYSTEMS

TECHNICAL FIELD

[0001] This invention relates generally to integrated circuit manufacturing equipment, and more particularly to equipment for chemical mechanical polishing.

BACKGROUND

[0002] Chemical mechanical polish (CMP) is a common practice in the formation of integrated circuits. Typically, CMP is used for the planarization of semiconductor wafers. CMP takes advantage of the synergistic effect of both physical and chemical forces for polishing of wafers. It is performed by applying a load force to the back of a wafer while the wafer rests on a polishing pad. Both the polishing pad and the wafer are then counter-rotated while a slurry containing both abrasives and reactive chemicals is passed underneath. CMP is an effective way to achieve truly global planarization over the entire wafer.

[0003] FIG. 1 schematically illustrates a conventional top-dispensing CMP system, which includes a polishing head 2, a membrane 4, a wafer 6 attached to the membrane 4, and a polishing pad 8, which is in contact with wafer 6 during the polishing process. Polishing pad 8 is attached to a plate 10, which spins at a constant rotation rate. A slurry-dispensing system 12 dispenses slurries to the surface of the polishing pad 8. Polishing head 2 moves back and forth between the center and the edge of polishing pad 8. Because of the movement of the polishing head 2 and polishing pad 8, slurry is distributed between wafer 6 and polishing pad 8 through trenches (not shown) in polishing pad 8. Chemicals and abrasives in the slurry thus work on wafer 6.

[0004] The top-dispensing CMP system has drawbacks. First, not all of the slurries are dispensed between the wafer 6 and polishing pad 8, thus a significant amount of slurry is wasted. Second, slurries always go under wafer 6 from its edge, and thus are likely to cause more polishing at the edge than in the center.

[0005] A bottom-dispensing CMP system is shown in FIG. 2. This system is similar to the top-dispensing CMP system except that the slurry is dispensed through a bottom dispensing system 14, which penetrates polishing pad 8 and dispenses slurry similar to the process of a fountain. This system has less waste, as slurries are able to be dispensed directly between the wafer 6 and polishing pad 8. However, removal of the used slurries is more difficult.

[0006] A new CMP system is thus required to take advantage of the benefits of the existing CMP systems while at the same time overcoming the deficiencies of the prior art.

SUMMARY OF THE INVENTION

[0007] In accordance with one aspect of the present invention, a chemical mechanical polish system includes a polishing pad, a plate supporting and rotating the polishing pad, a top slurry dispenser placed over a polishing pad, a bottom slurry dispenser placed through an opening in the polishing pad, and a duct connected to the bottom slurry dispenser, the duct extending toward the bottom of the polishing pad.

[0008] In accordance with another aspect of the present invention, a CMP system includes a polishing pad, a top slurry-dispensing system being configured for dispensing at least a first slurry component of a slurry from over the polishing pad wherein the top slurry-dispensing system comprises a first slurry storage, and a bottom slurry-dispensing system being configured for dispensing at least a second slurry component of the slurry from the bottom of and through an opening in the polishing pad, wherein the bottom slurry-dispensing system comprises a second slurry storage.

[0009] In accordance with yet another aspect of the present invention, a method for dispensing slurries for a chemical mechanical polish system includes dispensing at least a first slurry component of a slurry from a top dispenser placed over a polishing pad and dispensing at least a second slurry component of the slurry from a bottom dispenser. The bottom dispenser dispenses slurries from the bottom of the polishing pad and through an opening in the polishing pad.

[0010] In accordance with yet another aspect of the present invention, a method for dispensing slurries for a chemical mechanical polish system includes providing a slurry, the slurry comprising more than one separate component, categorizing the more than one separate components into a first component group and a second component group, dispensing the first component group from a top dispenser placed over a polishing pad, and dispensing the second component group from a bottom dispenser, wherein the bottom dispenser dispenses slurries from the bottom of the polishing pad and through an opening in the polishing pad.

[0011] The advantageous features of the present invention include significantly increased flexibility, reduced cost, and improved control of the CMP process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0013] FIG. 1 illustrates a conventional top slurry-dispensing CMP system;
[0014] FIG. 2 illustrates a conventional bottom slurry-dispensing CMP system;
[0015] FIG. 3 illustrates a CMP system including a top slurry-dispensing system and a bottom slurry-dispensing system;
[0016] FIG. 4 illustrates a cleaning system attached to the CMP system, wherein the bottom slurry-dispensing system and the cleaning system share a common duct;
[0017] FIG. 5 illustrates a cleaning system attached to the CMP system, wherein the bottom slurry-dispensing system and the cleaning system have separate ducts; and
[0018] FIG. 6 illustrates various placement schemes for additional slurry-dispensing systems.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0019] The making and using of the presently preferred embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

[0020] FIG. 3 schematically illustrates a preferred embodiment of a chemical mechanical polishing (CMP) system. A polishing head 22 is placed above a polishing pad 30. The
polishing head 22 includes a membrane 24, under which a wafer 26 is attached. The CMP system includes two dispensing systems, a top slurry-dispensing system 120 and a bottom slurry-dispensing system 220. Top slurry-dispensing system 120 includes a top slurry dispenser 122, a pump 124, and a slurry storage 126. Bottom slurry-dispensing system 220 includes a bottom slurry dispenser 222, a pump 224 and a slurry storage 226. Bottom slurry dispenser 222 penetrates polishing pad 30 through an opening and dispenses slurries upward onto polishing pad 30. Bottom slurry dispenser 222 is connected to a duct 230, which extends under polishing pad 30 and is connected to slurry storage 226. Bottom slurry-dispensing system 220 preferably includes a valve 228, which may be used for regulating the flow rate of slurries and/or for turning on/off the flow of slurries.

[0021] With the combination of top slurry-dispensing system 120 and bottom slurry-dispensing system 220, significant flexibility can be achieved, and customized requirements for different polish processes can be satisfied. This not only leads to an improvement in the polishing quality, but also to a reduction in cost. A significant advantageous feature for having dual dispensing systems is that components in slurries can be categorized into different groups and dispensed from different slurry-dispensing systems.

[0022] In a first embodiment, the components of the slurries are categorized as critical components and non-critical components. Preferably, non-critical components include those components that, regardless of whether they are dispensed from top slurry dispenser 122 or bottom slurry dispenser 222, the CMP results are not substantially affected. Examples of non-critical components include abrasives such as SiO2 or Al2O3 particles. Critical components preferably include components that are critical for the CMP process, such as components for enhancing polishing rate, corrosion/dishing control, and/or profile control. In an exemplary embodiment, copper corrosion inhibitor Benzotrazazole (BTA) is categorized as a critical component, and thus is preferably dispensed from bottom slurry dispenser 222.

[0023] In a second embodiment, the components of the slurries are categorized as more expensive components and less expensive components. Preferably, less expensive components such as abrasive particles and H2O2, are dispensed from top slurry dispenser 122, while more expensive components such as BTA are dispensed from bottom dispenser 222. Slurry components dispensed from bottom slurry dispenser 222 are less likely to be swiped off polishing pad 30 before they come into contact with wafer 26, and thus there is less waste. Slurry components dispensed from top dispenser 122, on the other hand, are more likely to be wasted.

[0024] Some of the slurry components cannot be premixed. For example, if abrasives and additives are pre-mixed, sediment is generated in the resulting slurry over time. In a third embodiment of the present invention, these types of slurries (un-pre-mixable) are preferably dispensed as separate components and then mixed on polishing pad 30. Un-premixable slurries preferably work on the wafer for a short duration after the mixing as they degrade with time. However, if they are dispensed from a same dispenser, more time passes before the slurries come into contact with wafer 26. If the slurry components are dispensed from different dispensers, however, chances are good that the different slurry components will remain un-mixed until the polishing head 22 swipes across the different slurry components and mixes them. The time duration between when the slurry components are mixed and when they come into contact with the wafer is thus significantly shortened.

[0025] In a fourth embodiment, the same slurry is dispensed from both top slurry dispenser 122 and bottom slurry dispenser 222, and the amount dispensed from the top and bottom can be the same or different. Slurry dispensed from bottom slurry dispenser 222 is more likely to work on the center of wafer 46, and thus tends to cause a greater polish rate at the center of wafer 46. Slurry dispensed from top slurry dispenser 122 is more likely to work on the edges of wafer 46, and thus tends to cause a greater polish rate at the edges of wafer 26. By pre-determining the profile of the polished wafer, the amounts dispensed from top slurry dispenser 122 and bottom slurry dispenser 222 can be adjusted to achieve a more uniform wafer surface.

[0026] It is realized that the CMP processes for metals, such as copper, and for non-metals, such as oxides, nitrides, and porous low-k dielectric materials, tend to rely on different mechanisms. The CMP of metal relies more on chemical effects (such as oxidation), while the CMP of non-metals relies more on mechanical effects (such as abrasion). Accordingly, in a fifth embodiment, slurry components having chemical effects are preferably dispensed from a different dispenser than slurry components having mechanical effects. In an exemplary embodiment, a faster CMP rate can be reached if H2O2, which oxidizes and thus softens copper, is dispensed from bottom slurry dispenser 222. Also, a different amount of H2O2 can be dispensed from bottom slurry dispenser 222 and top slurry dispenser 122 to further adjust the profile of the wafer.

[0027] De-ionized water may be dispensed from either top slurry dispenser 122 or bottom slurry dispenser 222, or both. Preferably, in the previously discussed embodiments, the dispensing of de-ionized water is not categorized using the previously discussed criteria. One skilled in the art will realize the optimum dispensing location of de-ionized water.

[0028] In a sixth embodiment, slurries or slurry components are categorized as clogging parts, which easily clog the trenches of polishing pad 30, and non-clogging parts, which are relatively easy to clean from polishing pad 30. Examples of non-clogging parts include, but are not limited to, abrasive particles. Preferably, clogging parts are dispensed from top slurry dispenser 122, while non-clogging parts are dispensed from bottom slurry dispenser 222. The clogging of polishing pad 30 is thus less likely to occur.

[0029] In the previously discussed embodiments, the dispensing from top slurry dispenser 122 and bottom slurry dispenser 222 may be performed using a synchronous mode or an asynchronous mode. In the synchronous mode, slurry components are dispensed from top slurry dispenser 122 and bottom slurry dispenser 222 simultaneously. In the asynchronous mode, slurry components are dispensed from top slurry dispenser 122 and bottom slurry dispenser 222 at different times. Due to the existence of more than one dispenser, the mode used affects the results of the CMP process. For example, to polish copper, hydrogen peroxyde (H2O2) is used for oxidizing, and thus softens the surface of copper. Copper oxide is then removed by abrasives. Copper corrosion inhibitor Benzotrazazole (BTA), on the other hand, slows down the CMP rate. Therefore, in an exemplary embodiment, BTA is dispensed from bottom slurry dispenser 222, while H2O2 is
dispensed from top dispenser 122. To fine-tune the CMP process, BTA and H$_2$O$_2$ may be asynchronously dispensed, wherein BTA is dispensed from bottom slurry dispenser 222, and thus works on the wafer 26 for a period of time before H$_2$O$_2$ is dispensed from top slurry dispenser 122 to slow down the CMP process. Conversely, BTA may be dispensed from top slurry dispenser 122, while H$_2$O$_2$ may be dispensed from bottom slurry dispenser 222 to speed up the CMP process. In this example, the duration between the dispensing of BTA and H$_2$O$_2$ determines the CMP rate.

[0030] Dispensing systems require periodic maintenance, which is commonly referred to as preventative maintenance. In a conventional CMP system including only one slurry-dispensing system, when the slurry-dispensing system is undergoing preventative maintenance, the entire CMP system has to be halted. With two or more slurry-dispensing systems, however, when one slurry-dispensing system is undergoing preventative maintenance, other slurry-dispensing system(s) can still support the operation of the CMP system. Therefore, the utilization rate of the CMP system is increased.

[0031] FIG. 4 illustrates a CMP system including a cleaning system 320. In one embodiment, cleaning system 320 includes a valve 328 and a pump 324, which are connected to bottom slurry dispenser 222. When bottom slurry-dispensing system 220 is functioning, valve 228 is open and valve 328 is closed. When cleaning system 320 is functioning, valve 328 is open and valve 228 is closed. Cleaning system 320 may perform two functions. First, it may dispense cleaning solution onto polishing pad 30. With separate valves 228 and 328, there is no need to empty slurry storage 226 in order to dispense the cleaning solutions. Second, cleaning system 320 may also evacuate used slurries from polishing pad 30. In alternative embodiments, bottom slurry-dispensing system 220 may have a separate conduit from cleaning system 320, and a respective structure is shown in FIG. 5.

[0032] The previously discussed preferred embodiments only illustrate two slurry dispensers, however, more slurry-dispensing systems can be added to suit the more customized requirements of the CMP process. The exemplary embodiments of the additional slurry-dispensing systems are illustrated in FIG. 6. In one embodiment, a third slurry dispenser 422 is placed over polishing pad 30 and dispenses slurries to a different point on polishing pad 30 than does top slurry dispenser 122. For example, the third slurry dispenser 422 is placed on an opposite side of polishing pad 30 from top slurry dispenser 122. In other embodiments, a third slurry dispenser 522 is placed next to bottom slurry dispenser 222, but dispenses different slurries (that are not pre-mixable) than does bottom slurry-dispenser 222. Each of the slurry dispensers 422 and 522 may be connected to a separate slurry storage for storing slurries as top slurry dispenser 122 or bottom slurry dispenser 222, thus may dispense the same slurries as top slurry dispenser 122 or bottom slurry dispenser 222. Alternatively, each of the slurry dispensers 422 and 522 may be connected to a separate slurry storage, and thus can dispense different slurries than those dispensed from top slurry dispenser 122 and bottom slurry dispenser 222.

[0033] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, machinery, and composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

1. A chemical mechanical polish (CMP) system comprising:
   a polishing pad;
   a platen supporting and rotating the polishing pad;
   a top slurry dispenser placed over the polishing pad;
   a bottom slurry dispenser placed through an opening in the polishing pad;
   a first slurry storage connected to the top slurry dispenser;
   a second slurry storage connected to the bottom slurry dispenser; and
   a duct connected to the bottom slurry dispenser, the duct extending toward the bottom of the polishing pad.

2. (canceled)

3. The CMP system of claim 1 further comprising a cleaning system, wherein the cleaning system comprises:
   a cleaning head placed through an opening in the polishing pad, the cleaning head being configured for performing at least one of the functions of:
   ejecting a cleaning solution onto the polishing pad, and evacuating a slurry from the polishing pad;
   a duct connected to the cleaning head; and
   a pump connected to the duct.

4. The CMP system of claim 3, wherein the cleaning head is the bottom slurry dispenser.

5. The CMP system of claim 3, wherein the cleaning head is a separate component from the bottom slurry dispenser.

6. The CMP system of claim 1 further comprising an additional slurry dispenser for dispensing slurries onto the polishing pad.

7. The CMP system of claim 6, wherein the additional slurry dispenser is connected to a third slurry storage.

8. The CMP system of claim 6, wherein the additional slurry dispenser is connected to a same slurry storage as one of the first and the second slurry dispensers.

9. A chemical mechanical polish (CMP) system comprising:
   a polishing pad;
   a top slurry-dispensing system being configured for dispensing at least a first slurry component of a slurry from over the polishing pad, wherein the top slurry-dispensing system comprises a first slurry storage; and
   a bottom slurry-dispensing system being configured for dispensing at least a second slurry component of the slurry from the bottom of and through an opening in the polishing pad, wherein the bottom slurry-dispensing system comprises a second slurry storage.

10. The CMP system of claim 9, wherein the top slurry-dispensing system and the bottom slurry-dispensing system...
are capable of dispensing synchronously and asynchronously.

11. The CMP system of claim 9 further comprising a cleaning system connected from the bottom of the polishing pad, wherein the cleaning system is configured to perform at least one of the functions of injecting a cleaning solution on the polishing pad and evacuating a slurry from the polishing pad.

12. The CMP system of claim 9, wherein the first slurry storage stores less expensive slurry components, and the second slurry storage stores more expensive slurry components.

13. The CMP system of claim 9, wherein the first slurry storage stores a first portion of a slurry, and the second slurry storage stores a second portion of the slurry, and wherein the first portion and the second portion cannot be pre-mixed.

14. The CMP system of claim 9, wherein the first slurry storage stores non-critical components of a slurry, and the second slurry storage stores critical components of the slurry.

15. The CMP system of claim 9, wherein the first slurry storage and the second slurry storage store a same slurry.

16. The CMP system of claim 9, wherein the first slurry storage stores non-clogging components of a slurry, and the second slurry storage stores clogging components of the slurry.

17. The CMP system of claim 9 further comprising a third slurry-dispensing system configured for dispensing slurries onto the polishing pad.

* * * * *