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Cleaning CMP Residues with Pre-wetted Wipers

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Process Residues

Semiconductor process equipment, over time, becomes contaminated with particles and process residues, adversely affecting the product being manufactured(1). To maintain process tool reliability, and ensure high product yields and overall quality, process equipment must be cleaned periodically. This cleaning can extend to floors, walls and ancillary mechanical equipment in order to maintain the overall appearance of the manufacturing facility and to preserve contamination control protocols in the fab.

Typically, cleaning is performed when particle levels reach unacceptable levels, when tools must be opened to replace consumables, or as part of scheduled preventive maintenance (PM). The effective removal of contaminants is aided by cleaning agents that are tailored to the specific materials being removed. Process residues must be cleaned from surfaces in a timely but effective manner to minimize the impact of contamination on tool productivity. This article addresses effective approaches to removing the process residues and environmental contamination encountered in chemical mechanical polishing (CMP) equipment.

The Problem with CMP

Oxide CMP processes employ slurries containing finely divided silica or alumina dispersed in a variety of chemical solutions. Unfortunately, over time CMP causes significant quantities of slurry to be deposited onto interior tool surfaces, tool skins, floors, nearby mechanical equipment and into the sub floor. The slurry then dries, leaving unsightly and potentially contaminating residues. Dried slurry can lead to wafer yield issues and cross-contamination of nearby environments and tools. Slurry residue fragments can find their way onto the CMP

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polishing pad and be ground into the surface of the wafer, causing scratches. Dried residue particles can be tracked from one room to another. Finally, the appearance issue cannot be ignored. CMP operators, fully garbed consistent with ISO Class 4 and 5 environments, may find it difficult to understand why contamination control protocols can't be relaxed if tool surfaces, equipment and floors appear unsightly and are encrusted with dried slurry residues. The intractable nature of these deposits have caused some facilities to postpone or abandon cleaning efforts.

Cleaning CMP Residues

Dried CMP residues cannot be dissolved with chemical agents, and having the consistency of cement, are difficult and tedious to remove by abrasion. Furthermore, abrasive removal of CMP residues is undesirable from a contamination control perspective, since there is the risk of sending large amounts of airborne particles into the fab environment ("No good deed goes unpunished"). So, if you can't dissolve them and abrading them only creates other problems, what's left?

Figure 1 – *Lower corner of CMP tool before cleaning. Black arrows show area to be cleaned.*

Figure 2 – *Black arrows show surfaces after a single cleaning. Some slurry removed, but multiple applications will be required to remove all the residue. Picture is somewhat out of focus.*

The best one can hope for is to re-hydrate the residues so that the silica and alumina particles that comprise the residues are converted back into an aqueous suspension, thereby releasing them from the surfaces to which they were bound. Cleaning systems consisting of wipers pre-wetted with appropriate cleaning agents are available for such applications. These systems incorporate abrasion-resistant, sealed-border polyester knit wipers wetted with a solution of deionized water containing a volatile surfactant. The surfactant helps promote the re-hydration process, encouraging the residues to absorb water. The wipers can withstand the abrasive character of the residue without shredding or generating particles or fibers. While this process does remove dried slurry residues, it should be recognized that it is time-consuming, since the residues don't re-hydrate instantly. The good news is that once the pre-wetted wipers are applied to the residue, operators can busy themselves with other tasks for 40 minutes to an hour before wiping up the removed deposits. Depending on the amount of residue

build-up and the intervals between cleaning, multiple applications may be required.

As a side note, it is worth pointing out that operators involved in cleaning CMP process equipment should be cautioned against using IPA as a cleaning agent for removing CMP oxide slurry residues. The dehydrating property of IPA that works so well for cleaning the majority of process equipment, has a detrimental effect on cleaning CMP oxide slurry residues. IPA dries the residues, causing them to harden and thus making the deposits much more difficult to remove from the various surfaces mentioned above.

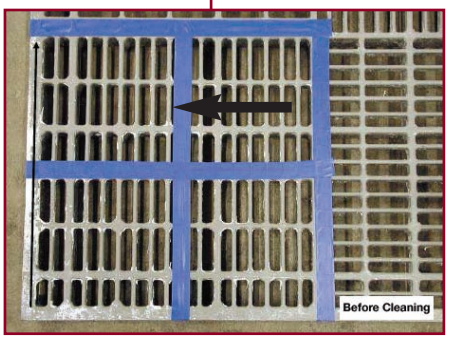

Figure 3 – *Floor grate before cleaning. Black arrow indicates the surface that will show the most dramatic results in Figure 4.*

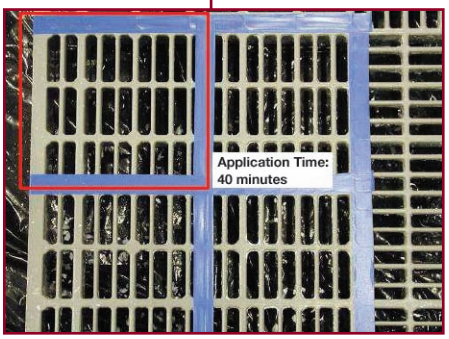

Figure 4 – *Floor grate after a single cleaning. Most of the residue was removed but some additional cleaning is required. Material under floor grate is a black plastic bag.*

A typical cleaning process involves applying a pre-wetted wiper onto the residue for 40 minutes. This allows time for the surfactant cleaning solution to penetrate and re-hydrate the slurry and loosen the adhesion between the slurry and the surface. (If the wiper becomes dry during the 40 minute period, the slurry will re-harden and once again bond to the surface. If this occurs, new wipers must be applied). After allowing the surfactant solution to wet the residue for the requisite period, the loosened debris can be wiped off the surface, trapped in the wiper material and discarded as hazardous waste. Tightly-adhering, wet deposits may be removable by gently scrubbing with the wiper or scraped away with a plastic scraper. If the residue does not come away from the surface easily, then re-application of more pre-wetted wipers is called for. For most applications, 9" x 9" (23 cm x 23 cm) pre-wetted wipers will suffice. Large 24" x 44" (60 cm x 110 cm) pre-wetted wipers can be used for vertical surfaces such as pipes and process equipment supports. The larger wipers are also used to clean large surface areas such as floors.

Typical results are shown in Figures 1 through 6. Oxide slurry residue appears as white deposits.

Figures 1 and 2 show the lower corner of a CMP tool before and after a single application of the pre-wetted wipers. Some removal of the oxide slurry residue was accomplished, but it is obvious that multiple

applications are required for complete removal. This tool had been in production for several years and had never been cleaned.

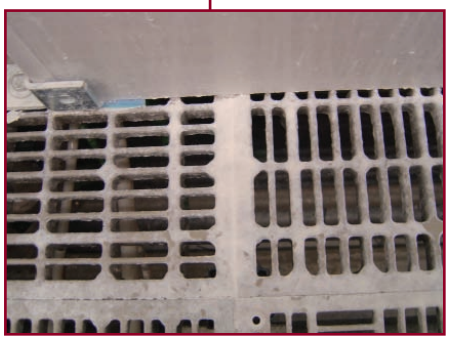

Figure 5 – *Floor grate adjacent to tool, before cleaning.*

Figure 6 – *Floor grate adjacent to tool after cleaning. Much residue removed, but additional cleaning applications will be required.*

Figures 3 and 5 show floor grates encrusted with oxide slurry residue prior to cleaning. Figures 4 and 6 show the corresponding grates after cleaning. Multiple applications of the pre-wetted wipers would be necessary to completely remove all of the deposited slurry residue. A final rinsing step to remove the cleaning agent from the surface is unnecessary, since the cleaning agent is a volatile surfactant and leaves the surface residue-free.

Summary

Wipers pre-wetted with a volatile surfactant have been shown to be effective in removing CMP oxide slurry residues from surfaces. Heavy deposits of residues need to be cleaned multiple times to remove all deposits. Incorporating regular cleaning steps such as these during equipment PM's lessens the need for heroic cleaning efforts later. Final rinsing of the surface is not required.

Reference

[1]H. Siegerman, "Applying Process-Specific Approaches to Performing Tool Preventive Maintenance", Micro, October, 2001.

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