

Copper Barrier CMP Filtration of Colloidal Silica Slurries

Point-of-Use Application

Shrinking geometries have led device manufacturers to prefer copper rather than aluminum metallization for interconnects because of its lower resistance to electrical current. This has resulted in faster processing times and reduced power consumption. Prior to copper deposition, a thin barrier of tantalum nitride, silicon nitride or ruthenium is applied to the dielectric layer to prevent copper migration. After copper deposition, the excess bulk copper and barrier layer (outside the vias) are removed by chemical mechanical planarization (CMP) in a two step process. In the first step, the majority of the copper is removed, leaving some residual copper along with barrier material. A second step is then used to remove the remaining undesirable materials.

Defects such as microscratches and chatter marks, which can occur after barrier CMP, have been attributed to oversized and agglomerated particles at the point-of-use (POU). Such defects can lead to either scrapped or reworked wafers, impacting fab yields. Filtration of the different slurries involved in each planarization step plays a major role in reducing these defects and lowering the cost of ownership (CoO).

The Challenge

The reduction of device feature size has led to a demand for cleaner colloidal silica slurries with fewer defect-causing particles. Along with this need to control defects, today's market demands require that a lower cost of ownership be part of the solution.

POU filtration plays a key role in any plan to manage defectivity and CoO. The first step is to select the correct filter grade to meet a defect target. Ideally, this filter will be in a capsule configuration, which is more compact and easier to handle.

Once a filter removal rating is established, the cost of ownership can often be reduced by optimizing filtration design. One successful approach can be the use of a larger capsule because it can provide increased life, leading to less downtime and fewer change-outs. Where space constraints in or near the polishing tool prohibit the use of these larger encapsulated filters, one of Pall's many smaller capsules can be selected. These are designed to maximize filter area for relatively long service life.

The Solutions

For Locations Near Polishing Tools

The Pall Kleen-Change® In-Line filter capsule was designed to meet and exceed the requirements of colloidal silica slurry filtration in advanced semiconductor manufacturing. As shown in Figure 1 (on next page), microscratch defects can be reduced five fold when using a Pall capsule containing a 0.3 micron Profile® II depth filter. Figure 2 (on next page) shows a relationship between a filter's surface area and on-tool life. Since the Kleen-Change capsule can have as much as five times the surface area of smaller capsules, there is a potential for up to a 20-fold improvement in service life with only a 2 – 4 fold price increase. There are a number of factors responsible for this phenomenon. When the same flow rate is maintained, the flux (flow per area) decreases in proportion to the increase in filter area. The initial differential pressure across the filter is thus correspondingly reduced, allowing for greater particle loading before reaching the terminal change-out pressure. In addition, filters retaining soft or gelatinous contaminants will usually exhibit much improved through-puts the lower the starting pressure drop.

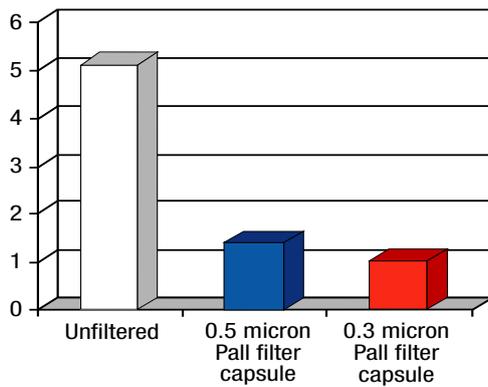


Figure 1. Microscratch defects in barrier CMP process

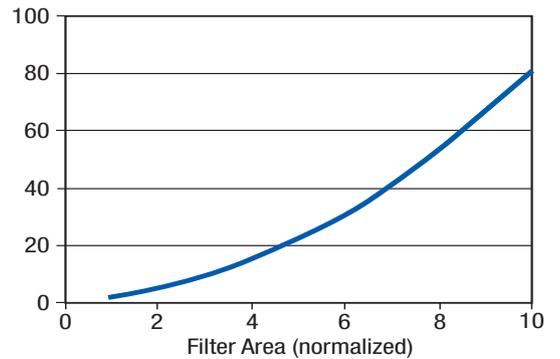


Figure 2. Relationship between filter area and service life with silica slurry

For Locations with Space Constraints

The Pall CMP StarKleen™ filter capsule was designed to provide a solution for CMP slurry filtration on or near the tool where there are size limitations or constraints. These capsules contain similar filter media to the Kleen-Change

In-Line filter capsules, thereby providing comparable defect reduction. They are available in lengths as small as 114.5 mm (4.51 in), making them ideal for some on-tool point-of-dispense applications.

Table I. Pall Kleen-Change in-Line Filter Capsule Attributes and Benefits

Product Attributes	User Benefits
Available in 0.3 micron grade	<ul style="list-style-type: none"> Provides very efficient removal of oversized particles leading to fewer microscratch defects on the wafer Fewer defects improves yields and lowers cost of ownership
Variety of capsule length options (including 365 mm and 622 mm lengths)	<ul style="list-style-type: none"> Can accommodate a range of flow rates Greater surface area can result in significantly longer on-tool life Longer intervals between change-outs can improve cost of ownership

Table II. Pall CMP StarKleen Filter Capsule Attributes and Benefits

Product Attributes	User Benefits
Available in 0.3 micron grade	<ul style="list-style-type: none"> Colloidal silica slurries filtered to this retention level typically meet or exceed barrier CMP defect requirements, even for advanced semiconductor manufacturing processes
Smaller capsule lengths (including 114 mm option)	<ul style="list-style-type: none"> Compact capsule dimension allows for installation at or very near the tool where the footprint does not permit the use of larger capsules Most effective in point-of-dispense applications



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