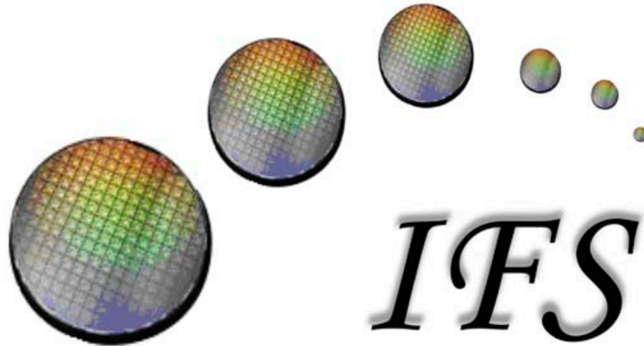

Pad Surface Manager™

NCCVAS CMPUG

March 19, 2014

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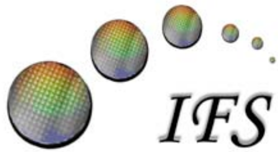
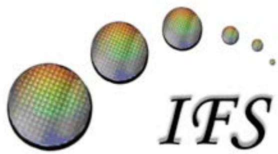


Introduction

The Pad Surface Manager™ (PSM™) functions quite simply like a carpet cleaner for the CMP polish pad. The PSM™ facilitates controlled cleaning of the polish pad during process by utilizing innovative pad conditioning tooling. With the addition of a new process Knob, suction, The PSM™ has proven repeatedly that by controlling the interfacial liquid residence and exchange, customers can significantly reduce slurry consumption, increase pad life, and improve defect performance. Results at three different customer sites have yielded dramatic performance improvements across several different thin films, slurries, and pad types. Of note are a major decrease in defects on an industry benchmark POR, and a major increase in removal rate with a 33% reduction in slurry consumption on a Ceria process with the PSM™.

The latest remarkable study was the PeTeos run recently performed on an AMAT Mirra™ CMP tool utilizing a very common consumable set and process parameters. In this study, 100 control wafers were run at the customer's POR and then the PSM™ was engaged for an additional 400+ wafers. The control wafers were within the historical range for Rate, Uniformity, and Defects of the POR. The PSM™ processed wafers exhibited an increased removal rate of approximately 7% and a major reduction in defects of approximately 70%.



Silica Slurry / PeTeos Data

Rate Without PSM™

Average 3777

Rate With PSM™

Average 4066

LPD's Without PSM™ Average 124

LPD's With PSM™

Average 35

• Without PSM™
• With PSM™

Test Wafer Lot A

Test Wafer Lot B

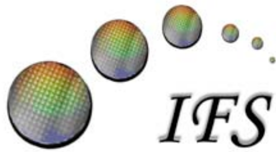
New Pad & End Effector

Defect Counts: 450, 350, 250, 150, 50, -50

Removal Rate: 4700, 4200, 3700, 3200, 2700, 2200, 1700, 1200, 700

Polish Minutes on Pad: 11, 12, 43, 63, 83, 103, 123, 143, 163, 183, 203, 223, 243, 263, 283, 303, 323, 343, 363, 383, 403, 423, 443, 463, 483, 503, 523, 543, 111, 112

Non-uniformity (not shown) was stable and unchanged across the run which averaged 3.65 @ 3mm



Silica Slurry / PeTeos Data

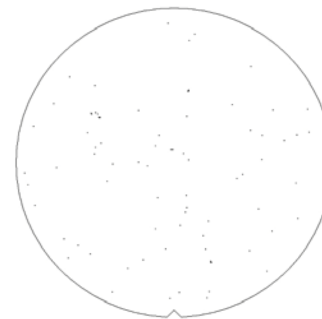
Process Test Date:	February 2014
Wafers / Film Type:	Novellus 40KA PeTeos
Main Polish Slurry / Pad Type:	DOW Klebosol 1501-50, Silica IC-1010 Grooved
Pad Conditioner End Effector:	TBW Grid Abrade for PSM
CMP Process Tool:	200mm Mirra running Titan II Heads

544 wafers were run with a test wafer placed after every twenty dummies. All wafers were PeTeos including dummies. All test wafers were run on the same head. Process was an industry-wide standard Oxide POR for 60 seconds on Platen 2 with PSM™ Conditioner and 60 sec buff on platen 3. Platen 1 was not used. For POR, PSM™ was used without Vacuum as a baseline. The first data point is wafer #11 after 11 min of polish and 41 min of conditioning (30 min Cond Break in). A Control Set of test wafers were run at the end without the PSM™.

Average Rate w/o PSM™ : 3777 Å/Min
Average Rate with PSM™ : 4066 Å/Min
Improvement of 7%

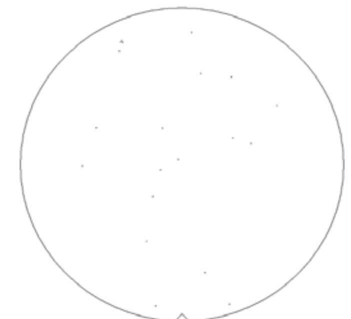
Average LPD's w/o PSM™ : 124 LPD
Average LPD's With PSM™ : 35 LPD
Improvement of 72%

Without PSM™

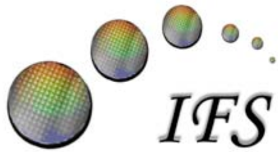


WaferID: 06
Inspection Time: 02/06/14
Defect Count: 191

With PSM™



WaferID: 25
Inspection Time: 02/06/14
Defect Count: 21



Ceria Slurry / TOX Data

150 ML Slurry
Without PSM™
Average 2151

150 ML Slurry
With PSM™
Average 2724

100 ML Slurry
With PSM™
Average 2471

Patterned Dummies
150 ML Slurry
With PSM™
Average 2890

Removal Rate
Average

Average 2.21% @ 3mm

Non Uniformity

Removal Rate

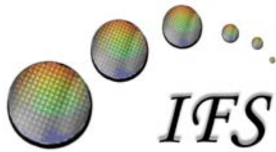
Wafer Count

0 1 2 3 4 5 6 7 8 9 10

0 500 1000 1500 2000 2500 3000 3500

38 61 84 107 130 153 176 199 222 245 268 291 314 337 360 383 406 429

Defectivity Data for this run was not available.



Ceria Slurry / TOX Data

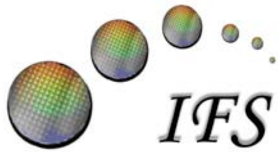
Process Test Date:	June 2013
Wafers / Film Type:	25KA TOX
Smain Polish Slurry / Pad Type:	Ferro SRS 2092, Ceria / DOW IC1000 K Grv
Pad Conditioner End Effector:	TBW Grid Abrade for PSM
CMP Process Tool:	200mm Mirra running Titan II Heads

429 wafers were run with a test wafer placed after every twenty dummies. Dummies were TOX. Dummy Wafers 389 and higher used patterned test wafers as dummies. Increase in removal rate in the wafers immediately following these patterned wafers is increased as an expected result.

All test wafers were run on the same head. Process was a standard Oxide POR for 60 sec on Platen 1 with PSM Conditioner and 30 sec buff on platen 3. Platen 2 was not used. For POR, PSM was used without Vacuum. The first data point is wafer #49 after 49 min of polish and 69 min of conditioning (20 min Cond Break in).

Average Rate w/o PSM™ : @150ml flow rate – 2141 Å/Min
Average Rate with PSM™ : @150ml flow rate - 2724 Å/Min
Improvement of 27%

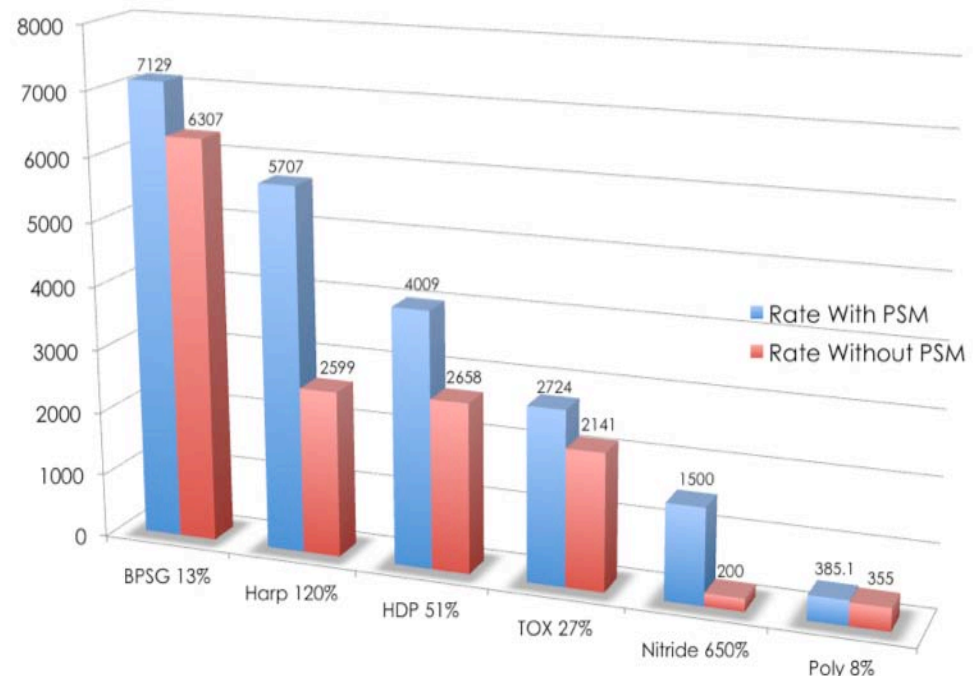
Average Rate with PSM™ : @100ml flow rate – 2426 Å/Min
Improvement of 13% while using 33% LESS Slurry

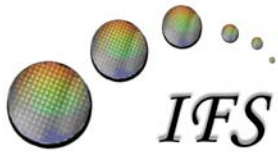


Other Film Types

In addition to the two experiments shown previously, the PSM™ is also proven to increase removal rate on many different materials. The wafers in this example were comprised of the last fifty wafers used as dummies at the end of the Ceria Slurry marathon run in between the TOX monitors. These wafers of varying materials and patterns were run within the PSM™ marathon to ensure that they were exposed to the same process parameters, consumables, and tool condition.

Far from being optimized processes, the results from this quick test show significant improvement in MRR for several films over the customer's historic removal rates, with Nitride being the stand-out performer at 650%. Further study with these films is ongoing to fully optimize this.





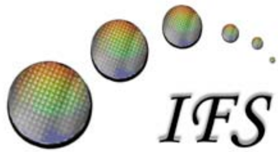
Effluent Management

Slurry Reprocessing

- The PSM™ removes of the effluent directly off the pad in-situ.
- As a result, the system could be employed to effectively feed a slurry reprocessing system with a more ideal mixture than drawing from the system drain.
- Past installations of slurry reprocessing systems have reportedly had to deal with inclusions into the feed material including but not limited to other wastes, such as floor cleaning materials, human organic materials, and oddly enough but not surprising, chewing gum.

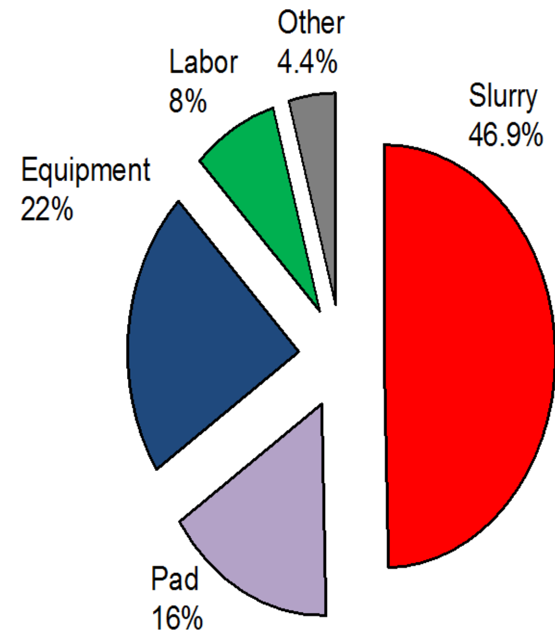
Waste Separation

- Additionally since the PSM™ captures over 95% of the input slurry, hazardous or incompatible wastes can be easily managed on existing equipment.
- Otherwise incompatible slurries can now be used on the same polisher as the “active” wastes are completely contained, and can be run to separate waste collection systems in the facility.



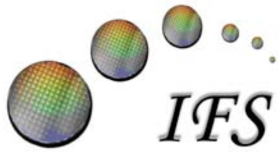
CoO Savings

Testing has proven that the PSM™ can reduce overall CoO by more than just a reduction in slurry. The PSM™ also has reliability and maintenance features over the OEM Conditioner cutting downtime, and increased pad life reduces PM time.



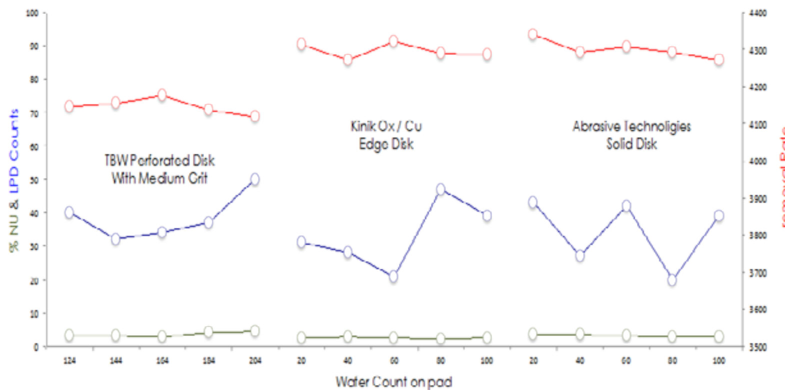
For a specific End User spending $4.5M per year per system for slurry consumption alone @ $4.50 / liter with an average of 65% actual process utilization, a 33% reduction in this cost equates to a savings of $1.5M per year, *<u>per tool.</u>*

Of course, each end user has different costs, utilization, and processes, but in the specific example stated, the cost savings are enormous, and pay for the PSM™ in only a few months.

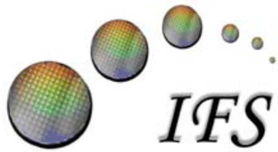


Materials

The PSM is not only able to run with TBW disks. IFS has collaborated with other makers of end effectors to give you the option to run an abrasive already qualified for your process for fast approval and implementation. There are currently Six types from three makers available, with others currently in development



The PSM™ was engineered with materials that are already in use and compatible with CMP. The housings are Hastalloy and the suction ring, the component which touches the polish pad, is PPS, just like the retaining rings, so there are no new materials to qualify, only the addition of suction.

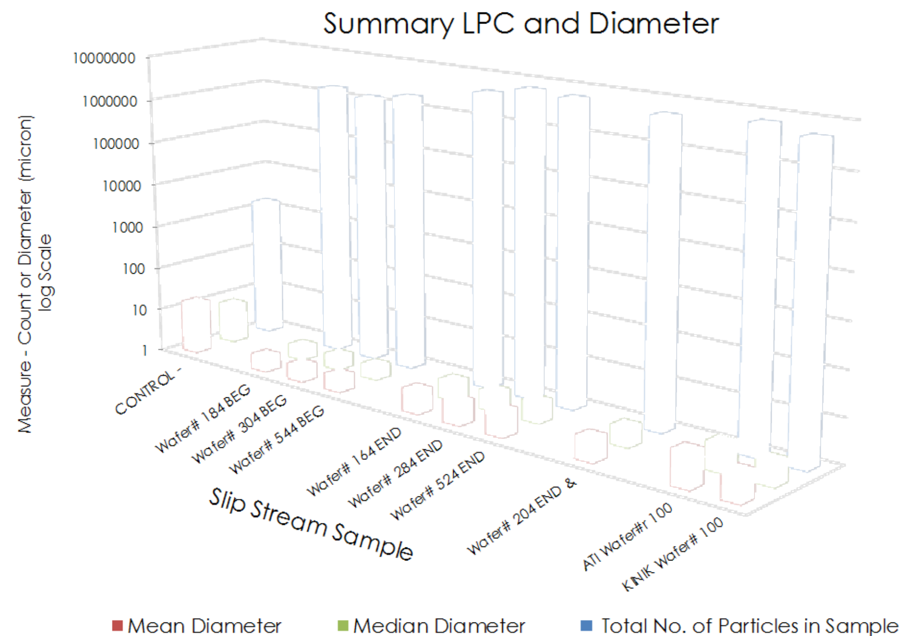


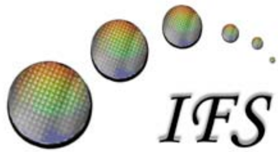
Conclusion

Using the PSM™ to manage the residence time for slurry, in this case, increasing the slurry turnover rate, has been shown to yield a higher MRR due to the wafer seeing a higher and more uniform concentration of oxidizer throughout the polish process, as predicted in Ref. [3] and [4] while at re same time reducing slurry consumption [1]. This results in a direct cost savings to the end user. The dramatic LPC reductions will likely overshadow the slurry savings at advanced nodes.

Using the in-line effluent sampling system designed within the PSM™ , we drew several samples of effluent across the PeTeos run. Using an Accusizer 780 we were able to characterize the oversize detritus contained in the slip stream. The chart shows the 3 order of magnitude increase in oversize particles otherwise entrained in the pads slurry film.

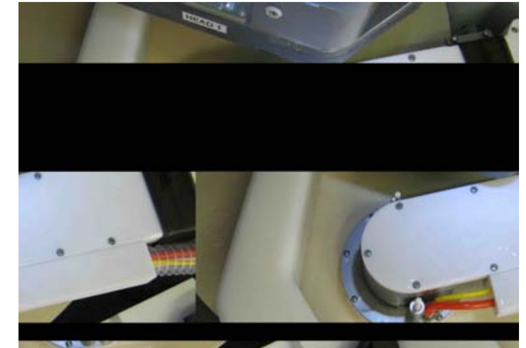
This innovation presents many opportunities for the end user to both monitor the composition of the detritus as well as to separate it at the point of use in a very simple and safe manner for isolation, disposal, or post treatment



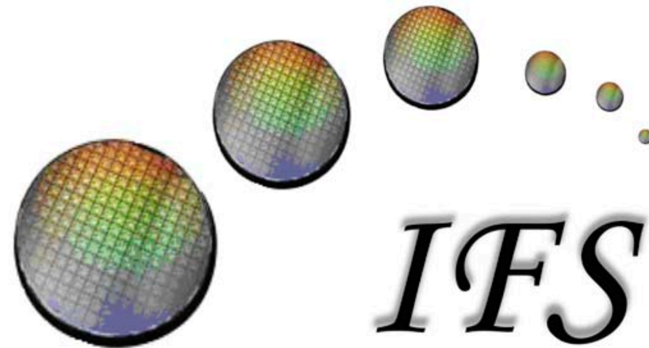


Conclusion

Proven Benefits of the PSM™



- Reduced slurry consumption, waste, and cost
- Reduced particle counts and defects on the wafer
- Improved end effector control resulting in longer life
- Improved clean end effector cleaning
- Extended pad life due to:
  - Larger sweep resulting in flatter pad profile
  - Lower downforce capability, accurate down to zero
- Ability to remove over 95% of the waste directly from the platen surface which:
  - Nearly eliminates carryover to next platen
  - Eliminates mixing of incompatible slurries in drain / on platens
  - Allows for simple separation of multiple waste streams from tool
  - Provides a non-contaminated material feed to slurry Re-processors
  - Allows for sampling of effluent in real time during process for both in-situ analytical measurement, and off-line analysis



Thank You!

IFS Remanufactures
CMP tools
and
Post CMP cleaning tools