Teaching Old CMP Equipment
A Few New Tricks

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Outline

Introduction

Tricks for Process Improvements

Tricks for Increasing Efficiency or Uptime

Tricks for Reducing Cost

Summary

Introduction

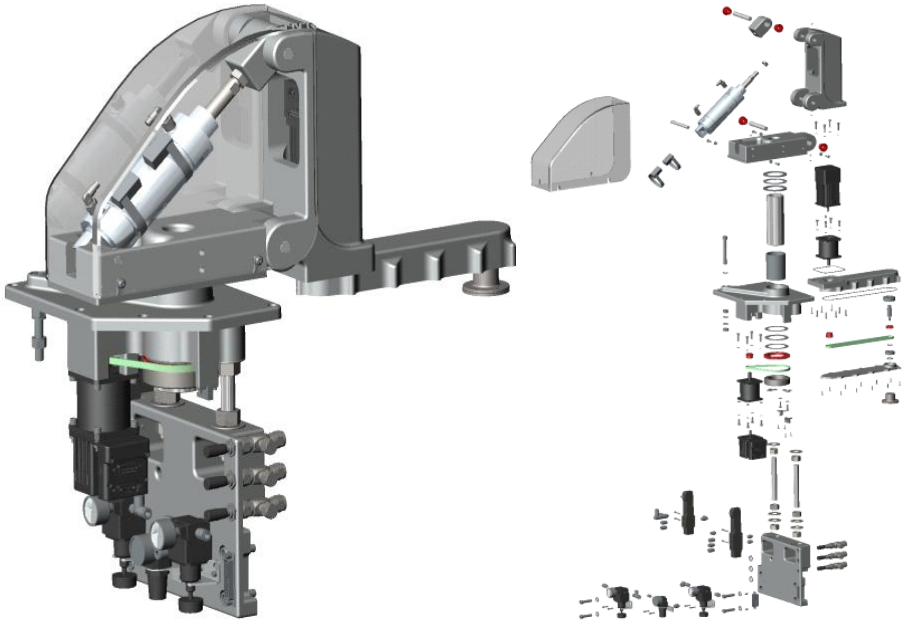
- A trademark of the semiconductor industry is relentless drive toward better, faster, & cheaper everything
- CMP has been around for >15 years in HVM and is now considered a mainstream process
  - Most of the first generation equipment is still on line even if now focused on different types of devices than advanced CMOS
  - Cost and performance improvements are constantly pursued
- As new materials are integrated, CMP also has to be adapted and redeveloped to meet changing demands

Pad Conditioning

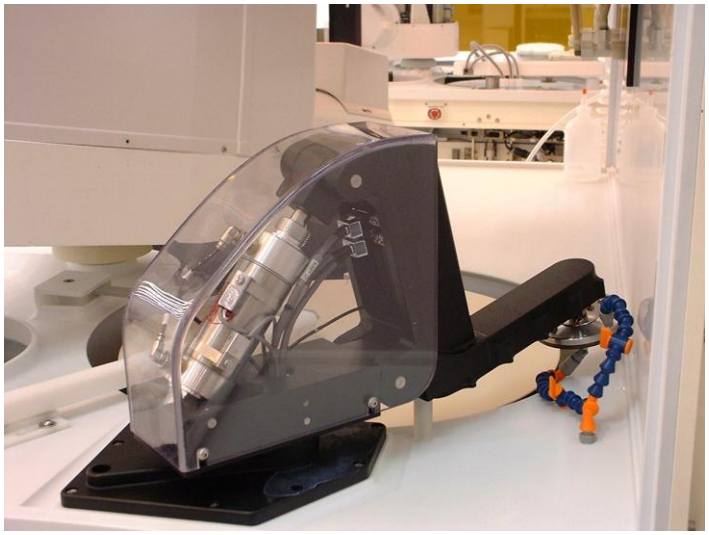
- Older generation pad conditioning hardware is prone to many of the following:
  - Very tricky alignments
  - Delayed response time due to load sensor and feedback loop integration time
  - Process drift due to inconsistent applied force
  - Overconditioning is the “norm” to ensure adequate force at all times
  - Parts obsolescence if/when components do fail

SteadySweep

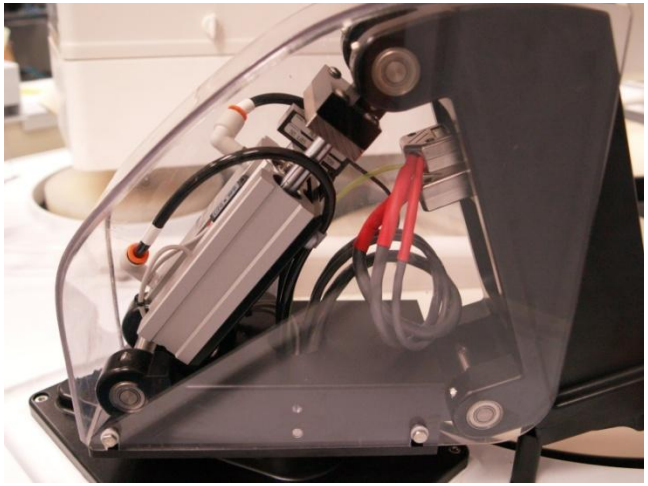
Conceptual Design Phase



Actual Field SteadySweep Retrofit

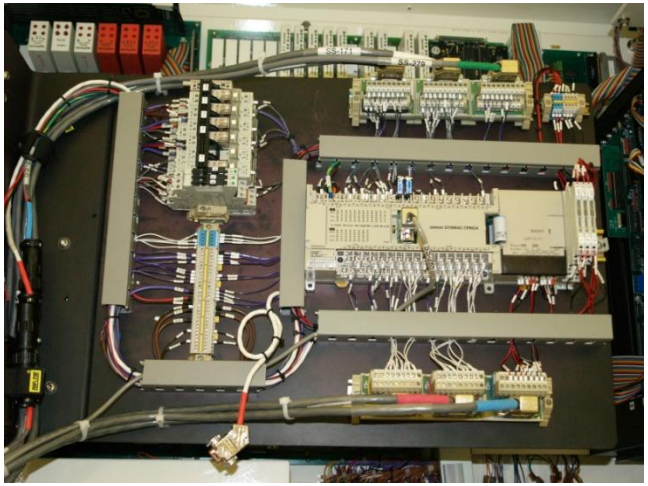


SteadySweep



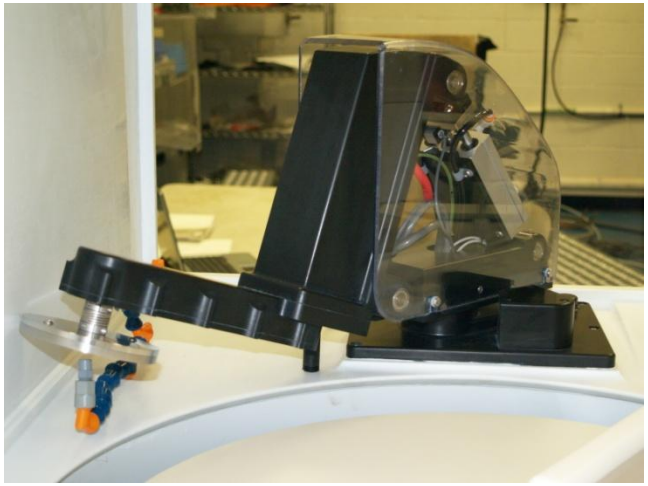
< Pressure control rather than load cell and feedback

> Swing arm panel in rear cabinet



< Simple controls below deck and mostly built from std components

> Sealed exterior for easy cleaning



Side by Side Comparison

472 with APP-1000™

372M with SteadySweep™

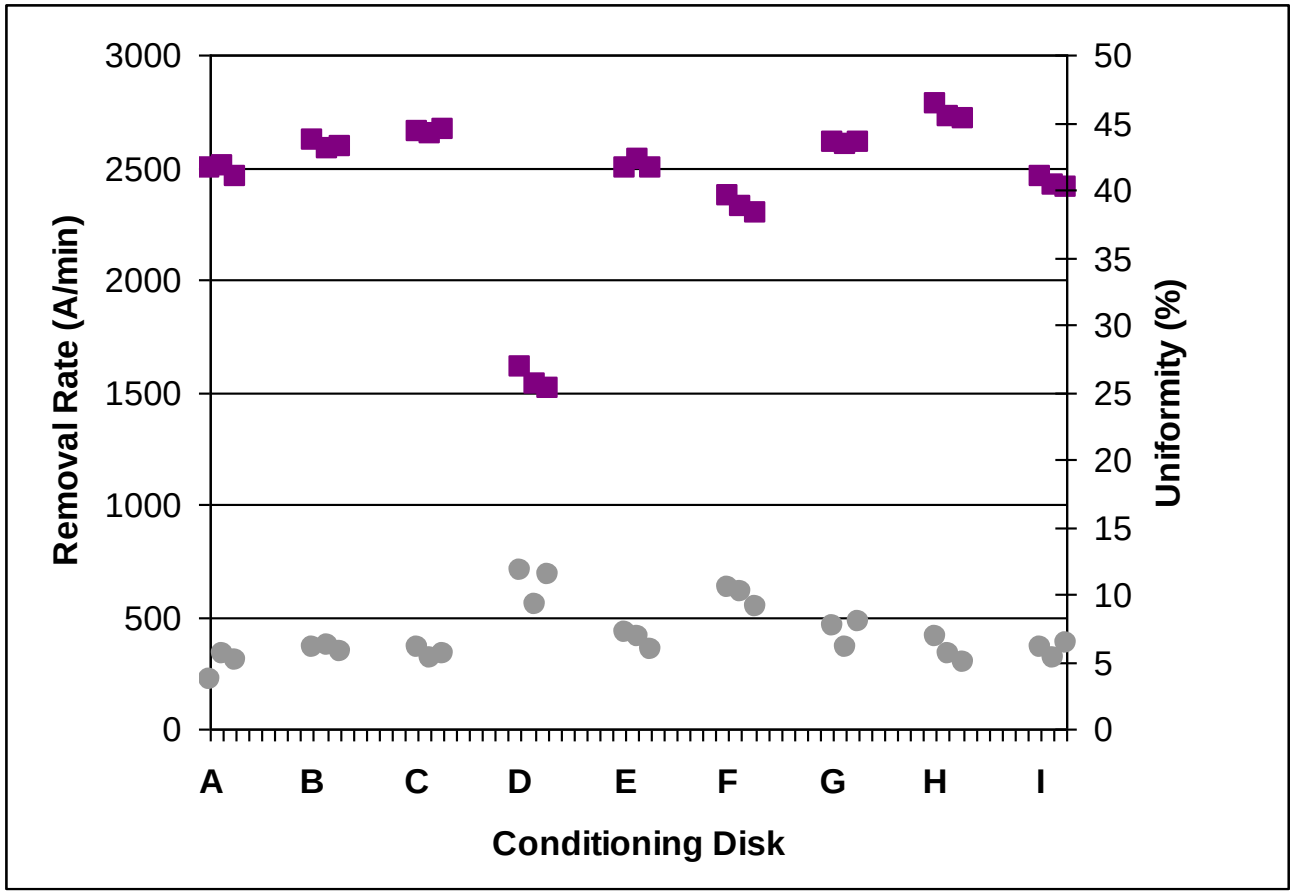
- Improved Serviceabilty – Provides easy access to platen motors, gear boxes, etc.
- Safety Features – SteadySweep™ is fully interlocked with polisher safety features
- Simple Controls – PLC controller with ladder logic programming to monitor and activate SteadySweep™ by using the digital I/O signals of the polisher

Multiple Disks

SteadySweep™ using most major brands of conditioning disks in back-to-back trial.

All tests performed on the SAME IC1000 pad.

Expt conditions:
4 lbs applied force
15 min breakin
10 min filler wafers
3 rate wafers
Repeat for next disk

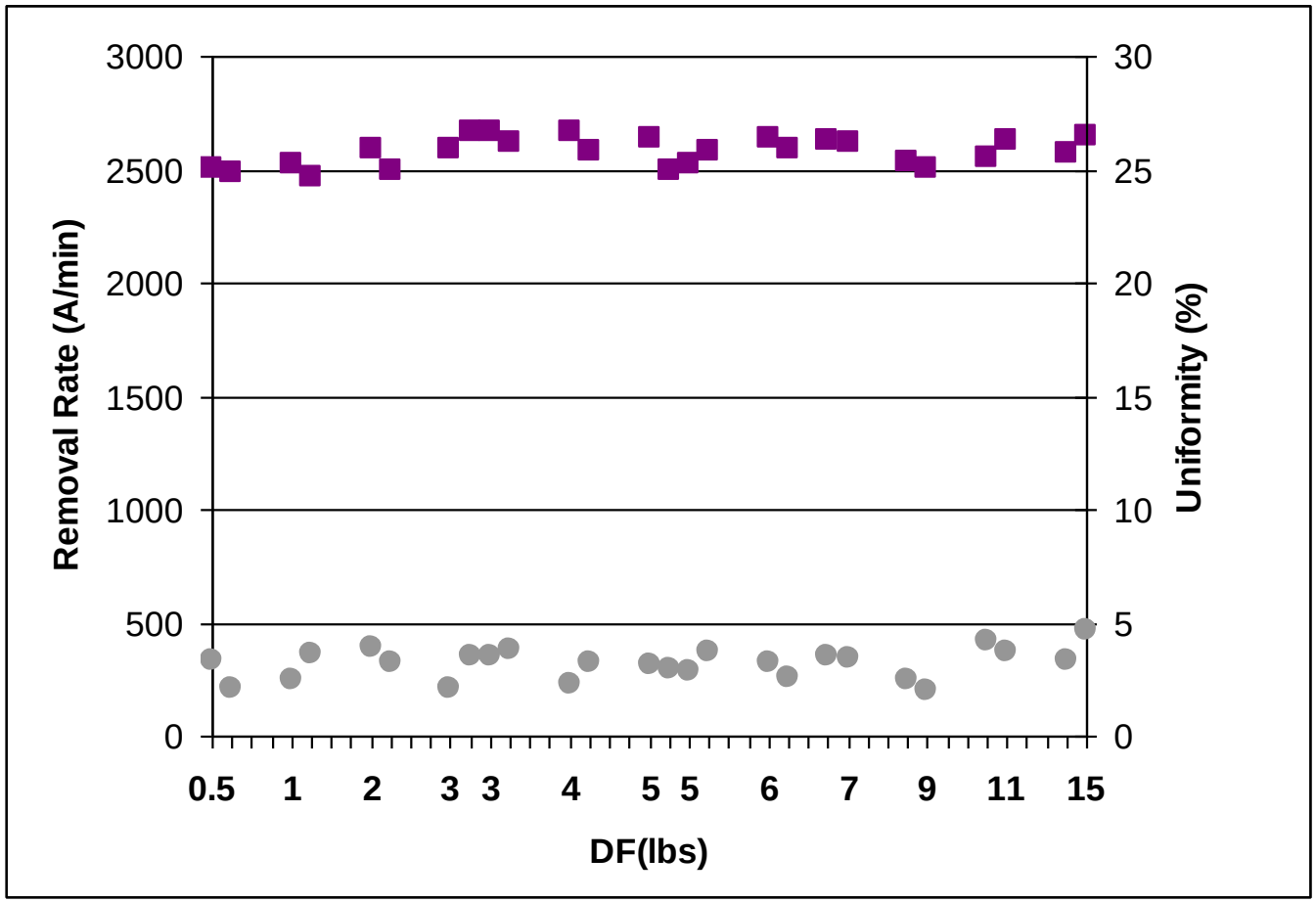


Characterization

Multiple runs on same pad in a random sequence

Consistent rate and uniformity

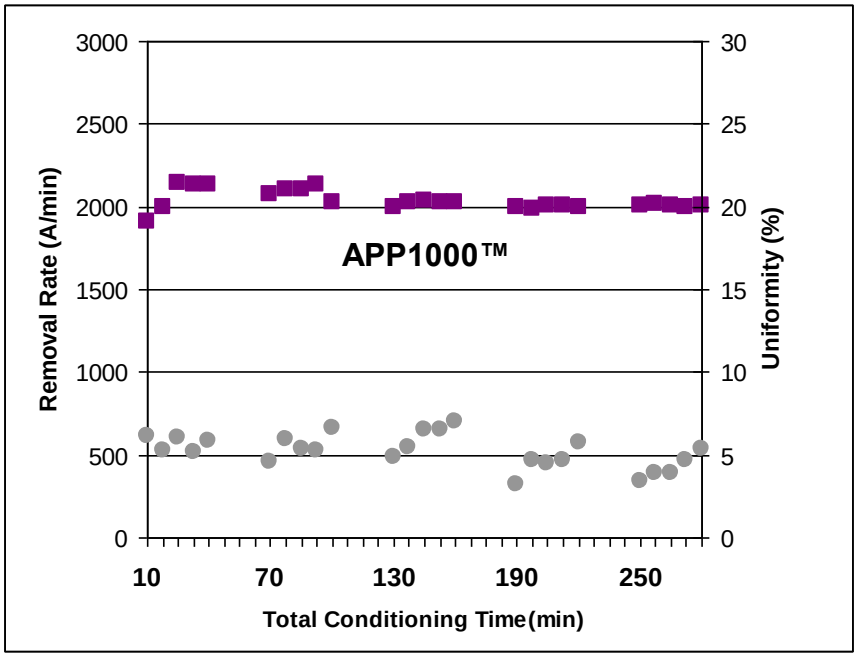
Very slight drop in rate at applied forces of 1 lb and 0.5 lb.



Pad stack: IC1000 on Suba IV
Slurry: Cabot SS-12
DF = 7psi, Platen speed = 40 rpm
SteadySweep™ in-situ conditioning

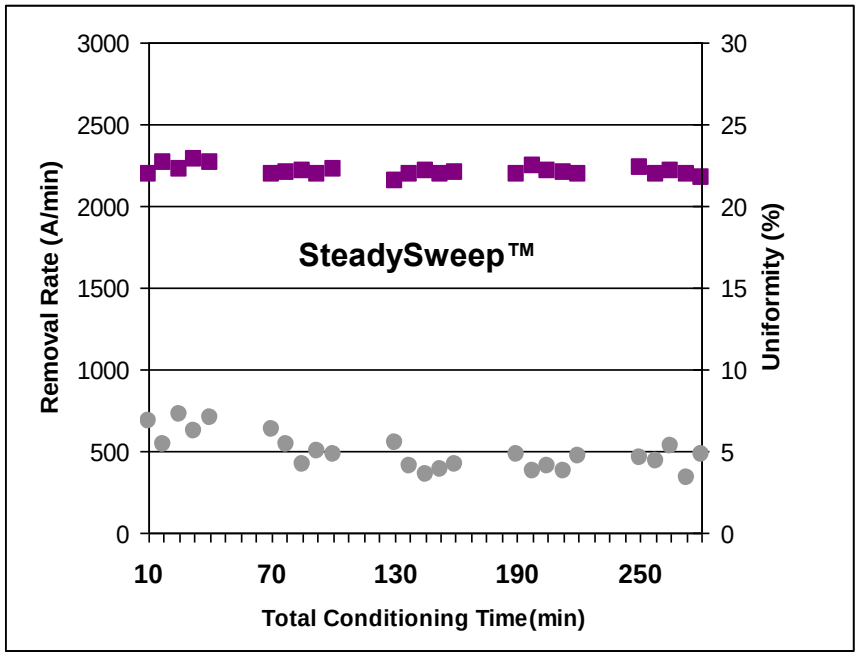
Marathon

APP1000™: at **8 lbs** conditioning down force



Result: *Slight Removal Rate decay through four (4) hr run.*

SteadySweep™: at **2 lbs** conditioning down force



Result: *Near zero Removal Rate decay and improved uniformity through four (4) hr run.*

Standard Oxide Process: Pad stack – IC1000on Suba IV; Slurry – Cabot SS-12; Polish DF = 7 psi; Platen speed = 40 rpm
NOTE: Same polish head and conditioning disk was used or both sets of data shown above

SteadySweep Specs

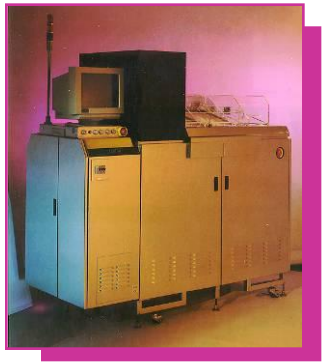
Force	**0.5 to 20 pounds**
Rotational Speed	**0 to 200 rpm**
Modes of operation	**1. Breakin (new pad)** **2. In-situ (during polish)** **3. Ex-situ (between wafers)**
End effector size	**2 inch through 7 inch diameter** **(custom sizes upon request)**
Platforms supported	**IPEC 372, 372M, 472** **Strasbaugh 6DS-SP, 6EC, etc.** **Virtually any rotational polisher**

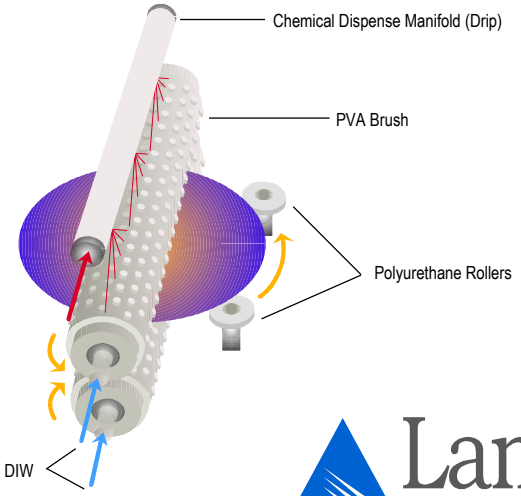
OnTrak Systems

Series II Classic or CE

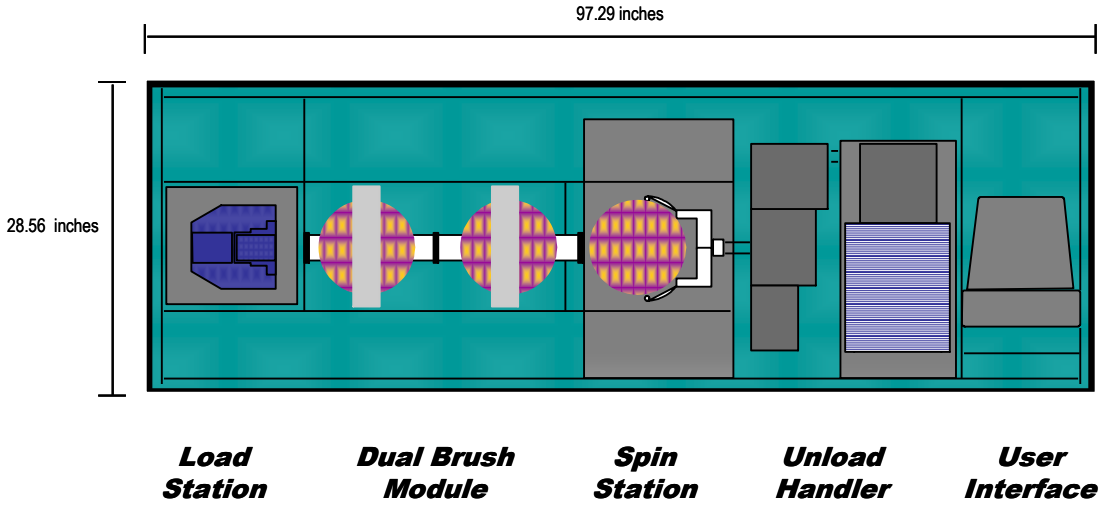
Synergy

Synergy *Integra*



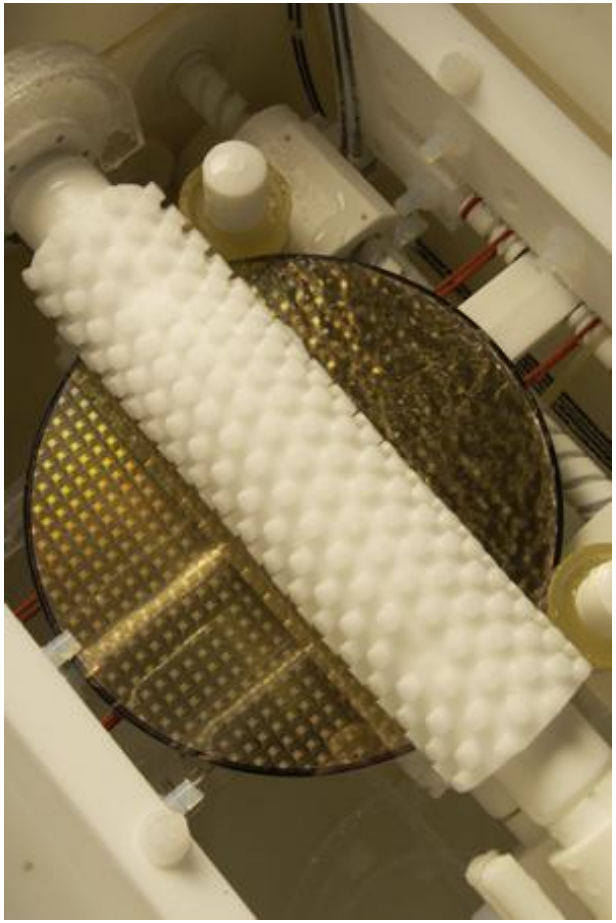


Lam RESEARCH



OnTrak brush module

- Double-sided scrubbing with PVA brushes is the most commonly used approach for post-CMP cleaning
- Thousands of installed systems worldwide (including OnTrak, DNS, integrated cleaners on DIDO tools, etc.)
- All systems include wafer sensors for feedback and control



Clear Wafer Issues

- A growing number of applications require processing of transparent or low opacity substrates, such as glass, sapphire, quartz, SiC, etc.
- Typical configuration uses through beam sensing to detect the presence or passage of opaque substrates.
- Clear substrates are not detected by through beam sensors nor most standard capacitive sensors. In dry environments, reflective sensors are a good solution.
- Post-CMP cleaning environment involves liquid sprays, highly polished metals, wet plastics, and other reflective surfaces which generate “noise” to the typical reflective sensor.
- Attempts to tune a standard reflective sensor to detect only the substrate and not the liquid overspray or materials were ineffective.

Sensors Resolved

- **New sensor types employed for clear wafers**

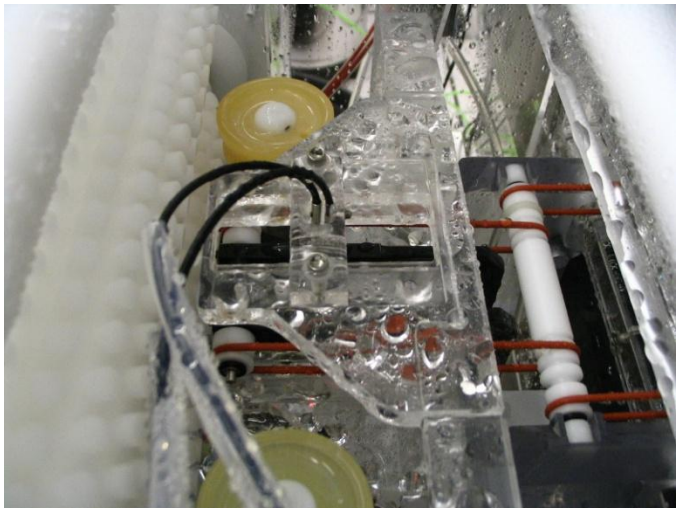
1) Sensor Type 1

- **Allows detection of a surface at a specific point (+\-.02”).**
- **Mounted near to the product surface (1-2” preferred).**
- **Uses a digital amplifier to suppress “noise” generated by background surfaces or water droplets.**

2) Sensor Type 2

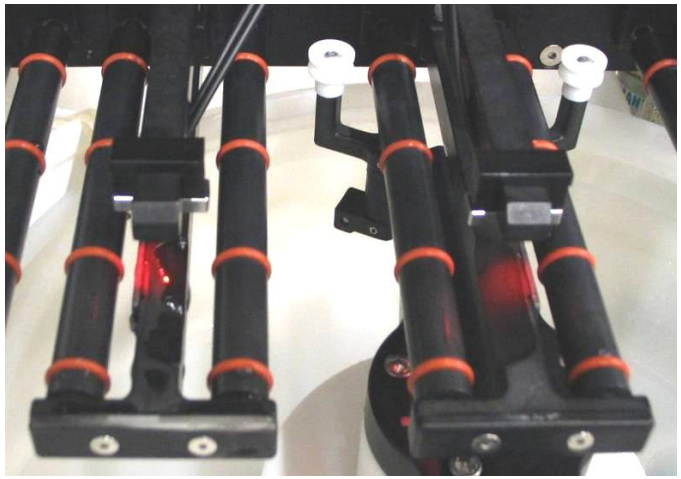
- **Enables longer distance sensing**
- **Amplifies attenuation in received light even as it passes through a clear surface.**

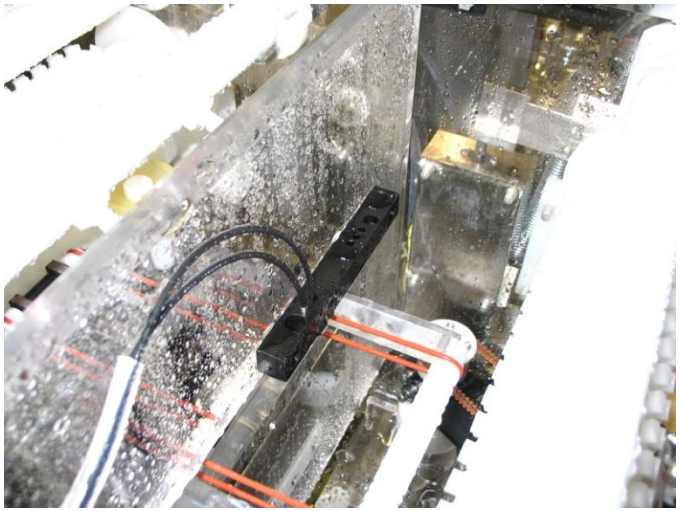
Sensor Locations



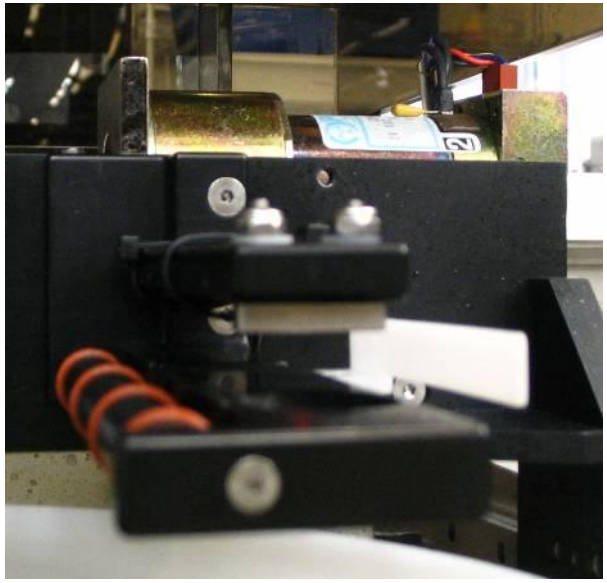
Multiple Sensors:

Load station
Brush box #1
Brush box #2
Transfer carriage
Spin station
Unload station





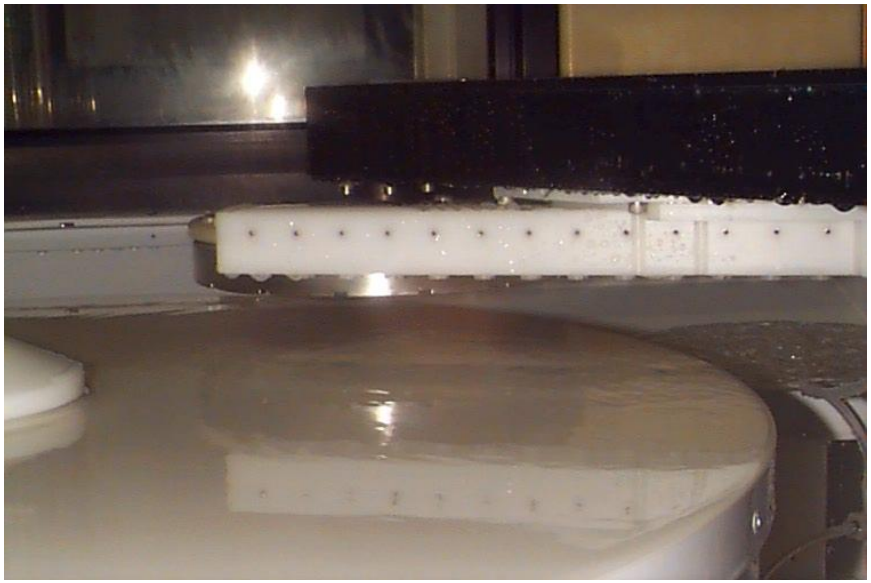
Net Result:
Enables clear wafer processing on OnTrak double sided wafer cleaning tools



Spray Bar

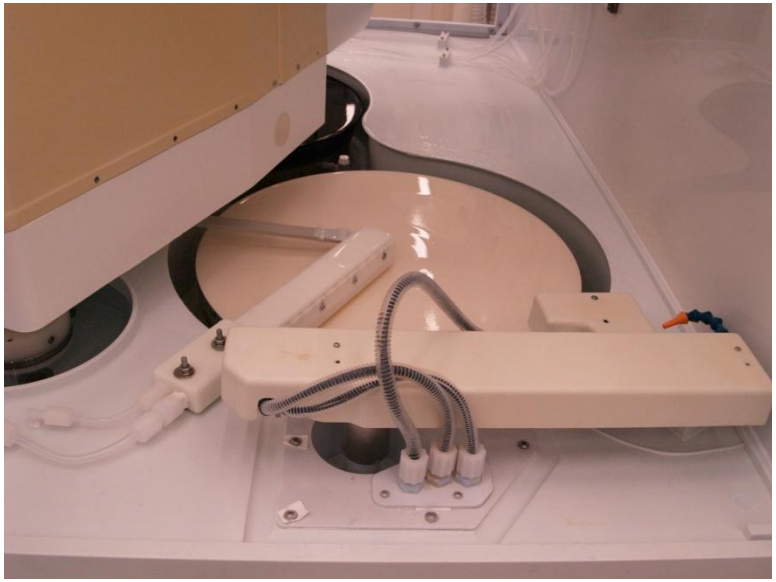
- Pad rinse occurs at end of polish or between wafers
- Spray bar helps remove agglomerates, pad fragments, and other surface debris → especially from grooves
- Lowers defectivity
- Improves yield with minimal investment
- Best performance achieved with atomizer design using both DIW and N2 to create high velocity spray

Spray Bar Photos

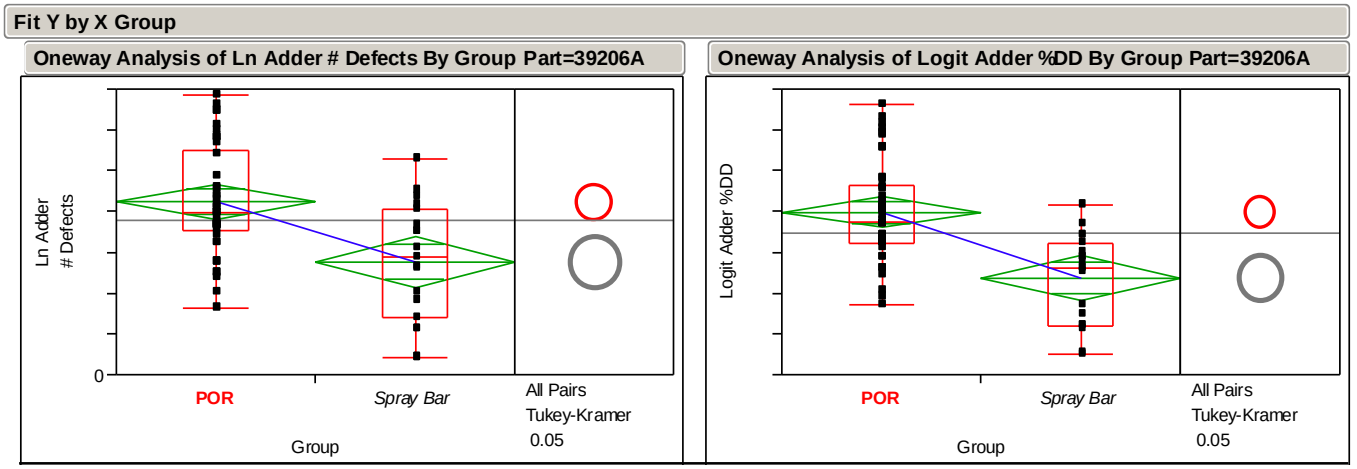


Spray bar installed on
Auriga polisher (above)

Spray bar installed on
IPEC polisher (below)



Defect Improvement

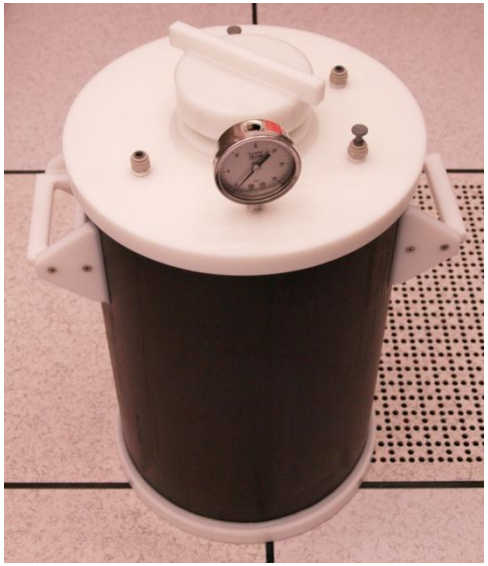


Statistically validated reduction in defect levels with addition of spray bar

Polymer Pressure Canister

- In many facilities, cleaning chemistry is fed to the scrubbers from stainless steel pressure canisters
- Most canisters are treated to reduce leaching of metals, but this can break down or be destroyed by some chemicals
- Preferred solution is a canister of all polymer construction

Polymer Pressure Canister



Pad Applicator

- All pads have PSA layer to adhere them to the polisher platen
- Air bubbles under the PSA can cause defects or nonuniformity or wafer slipout (worst case)
- Simple solution involves training and using a tool to apply uniform pressure

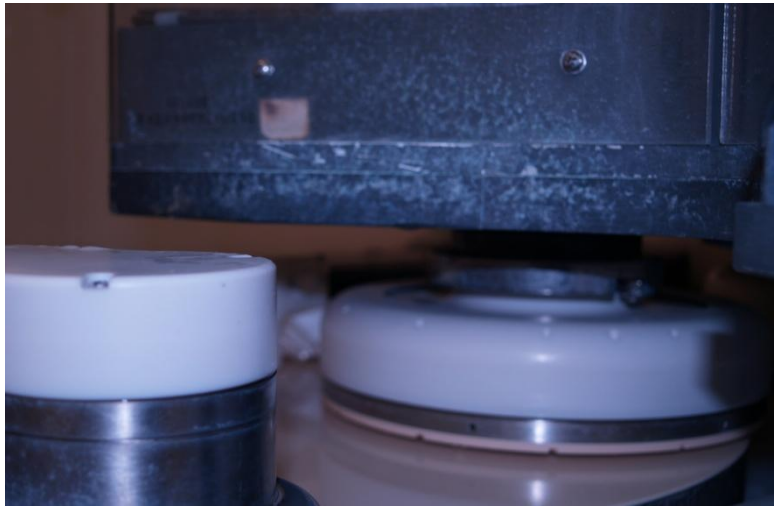
Pad Applicator

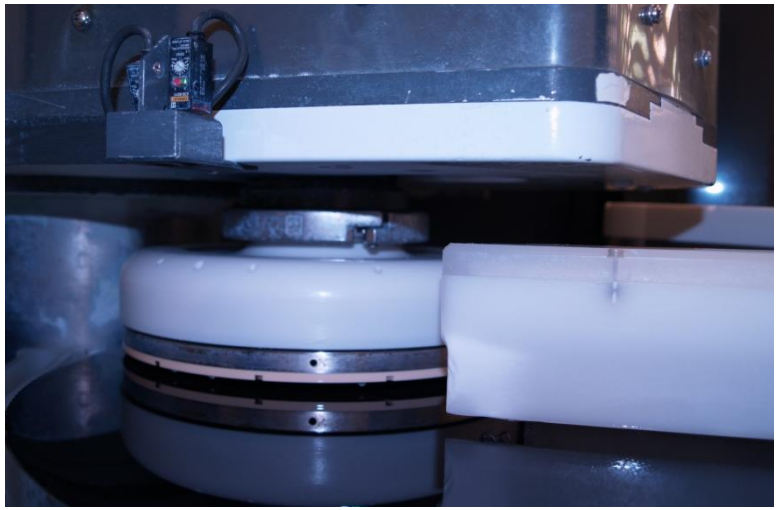
Pad Puller

- Changing pads on IPEC 472 polishers can be awkward and difficult for some people
- Ergonomics were not a primary factor in original design
  - Requires leaning across the APP-1000
  - Physical strength required depends on pad PSA
- Custom designed solution involves a cable, air cylinder, and unique pressure clamp

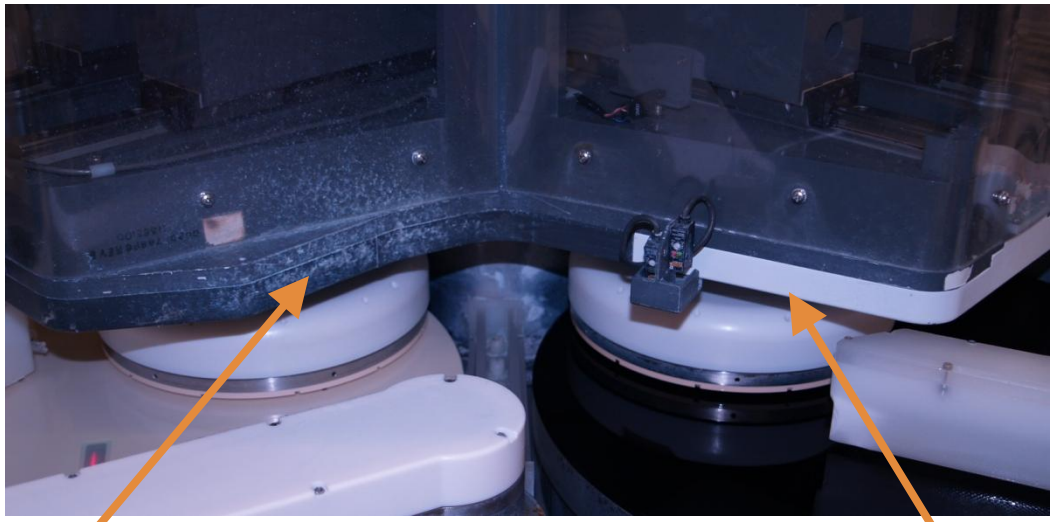
AMAT Arm Shroud

- Cover or shroud on bottom of arm is often splashed with slurry
- Builds up over time and dried slurry agglomerates can fall back onto pad
- Frequent cleaning can actually roughen surface and enhance buildup
- Improved approach is to coat with smooth finish





AMAT Arm Shroud



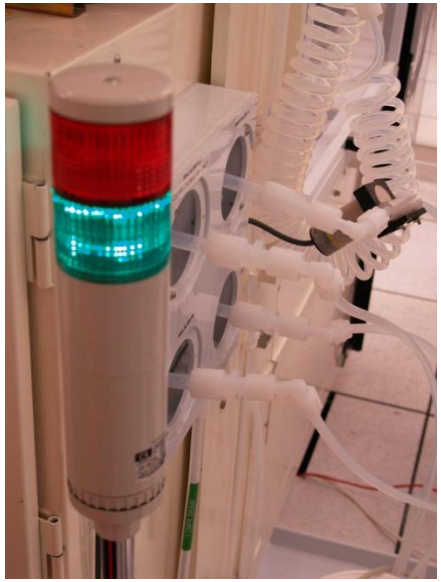
Standard Shroud

Coated Shroud

Reducing buildup on surface above the pad reduces risk of fall-on particles

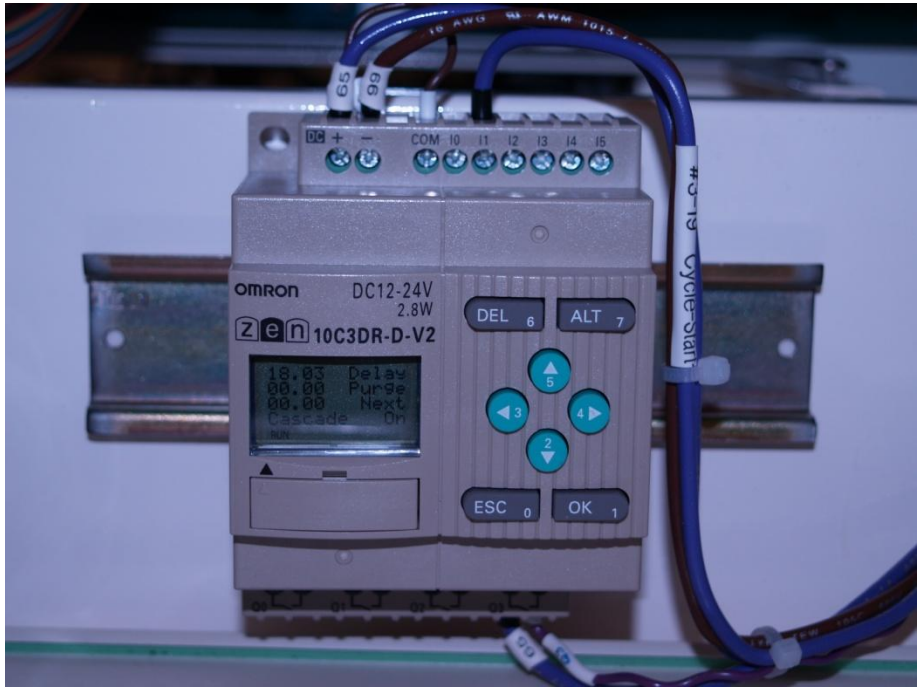
Slurry Level Alarm

- Most production facilities deliver slurry through pressurized distribution systems … development facilities often do not
- An empty bucket or unfilled feed line causes at least an excursion and at worst a broken wafer
- Solution = Sensors and simple alarm tower



Idle Water Savings (IPEC polishers)

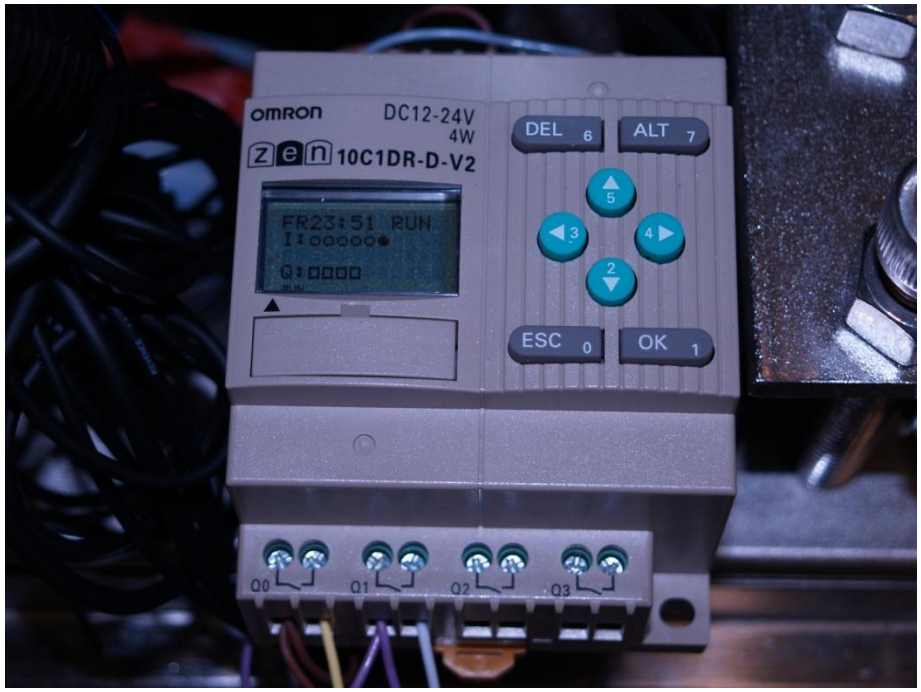
- In idle mode, most polishers still consume substantial DI water
- On IPEC tools, unload tub overflow is a major contributor
- Auxiliary timer and valve enables control of overflow when tool is in idle mode
- Tub dump/refill is not affected



Over 30% reduction in monthly DI water consumption at the beta facility !!

Idle Water Savings (OnTrak scrubbers)

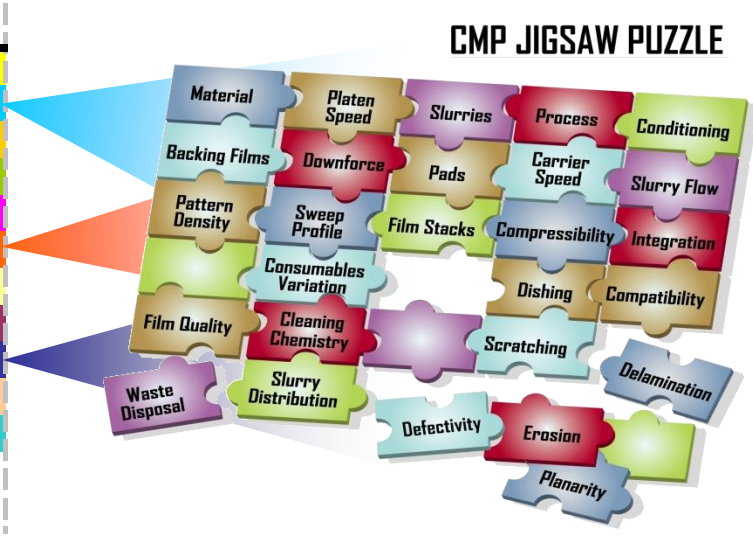
- In idle mode, OnTrak cleaners consume substantial DI water
- Software allows only minimal control over brush rinse and turning down flow meters can negatively impact process
- Auxiliary timer and valve enables control in idle mode and is deactivated when running process
- Data shows at least 30 minutes between rinse cycles is safe



Over 50% reduction in monthly DI water consumption at the beta facility !!

CMP Applications

1995 - Qty ≤ 2	2001 - Qty ≤ 5	2009 - Qty ≥ 36		
CMOS	CMOS	CMOS	New Apps	Substrate/Epi
Glass (oxide)	Glass (oxide)	Glass (oxide)	Doped Oxides	GaAs
Tungsten	Tungsten	Tungsten	Nitrides	GaN
	Copper	Copper	NiFe & NiFeCo	InP
	Shallow Trench	Shallow Trench	Noble Metals	CdTe & HgCdTe
	Polysilicon	Polysilicon	Al & Stainless	Ge and SiGe
		Low k	Polymers	SiC
		Cap Ultra Low k	Ultra Thin Wafers	Diamond & DLC
		Metal Gates	Direct Wafer Bond	Si & Reclaim
		Gate Insulators	Through Si Vias	SOI
		High k Dielectrics	3-D Packaging	Quartz
		Ir & Pt Electrodes	MEMS	Titanium
		Magnetics	Nanodevices	
			Integrated Optics	



As CMP applications continue to multiply … optimized consumables, processes and methods must be developed with lowest possible risk and cost

Topics

- SteadySweep
- Clear Wafer Sensors
- Spray Bars
- Polymer Pressure Tanks
- Pad Applicator
- Pad Puller
- AMAT Lower Arm Shroud
- Slurry Indicator Tower
- Water Saving Controllers

- Upgrades & modifications should be tailored to the needs of each facility
- Unexpectedly large benefits can come from some very low cost items
- The best source of what needs improving is often from the people running the tools every day

Acknowledgements

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  - Paul Lenkersdorfer, Donna Grannis and Terry Pfau (process team)
  - Roy McCoy, Josh Beckenhauer and the rest of the equipment team
  - Customers who gave permission to use images and data
  - Bill Easter of SEMPlastics for spray bar and arm shroud information

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