Filtration Solutions for Management of Defectivity Associated with Data Storage CMP

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OUTLINE

- Defining the need for CMP slurry filtration
- Issues associated with slurry filtration
- Addressing CMP filtration issues
- Ensuring filter “transparency” for CMP slurries
- Filtration for HDD CMP
- Defect reduction via filter selection
- Exploration of filter configuration
- Identifying and addressing future needs and directions

On the Need for Filtration of CMP Slurry

- Demonstrable link exists between oversized particles and defects occurring during the CMP process
  - Known to hold true for HDD as well as semiconductor processing CMP
- Particle size distribution (PSD) data of as-received CMP slurry abrasive virtually always reveals *some* oversize particles, These occur despite extensive processing steps to sharpen the PSD
- Handling of CMP slurry can induce agglomeration
  - For example, shear induced agglomeration due to various reasons

As such, filtration at some suitable removal rating is generally needed

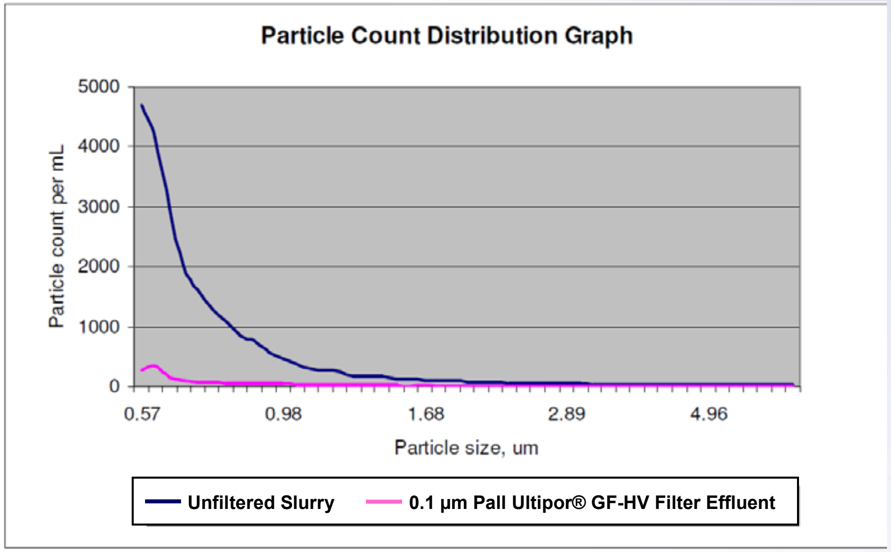
Potential CMP Slurry Filtration Issues

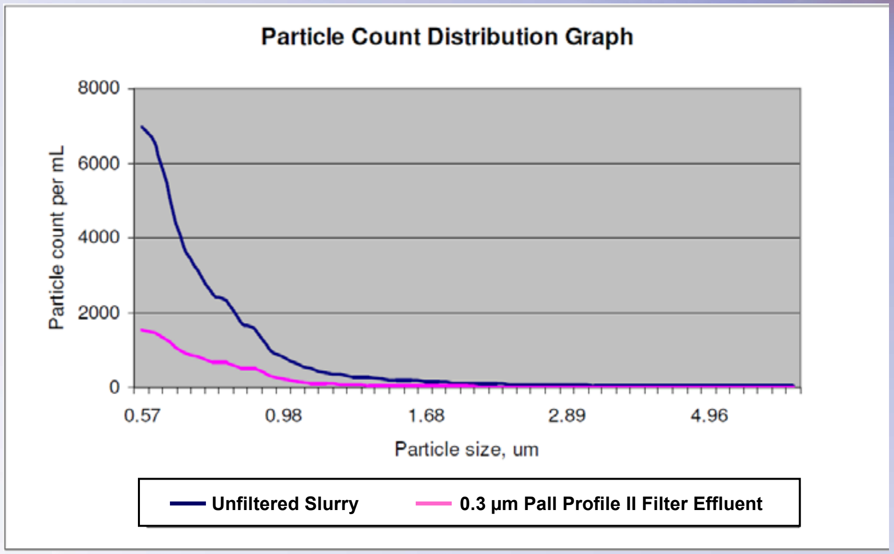
- Will the filter remove particles of the *desired* size in addition to the oversize particles?
- Will filter behavior change (with respect to effluent PSD) as it loads with large particulate?
- Can good flow properties and reasonable life be achieved with a particle laden process fluid?

Filter Construction, Configuration, and Usage: Impact on Performance

- Transmittance *vs.* retention for CMP slurries
  - Reasonable particle size “cut-off” is often realized using filters having fibrous construction, *e.g.* melt-blown polypropylene or wet-laid inorganic fiber filters
    - Stripping of “active” particles may be more likely with cast membrane
- Achieving optimal filter performance
  - Can be attained via suitable construction that takes advantage of inherent capture mechanisms and flow properties of the fibrous morphology
- Achievement of suitable flow and life
  - May be realized by optimizing filter depth (or media thickness), availability of filtration area, porosity, and asymmetry of pore structure
    - Also possible to combine depth and pleat structure to enhance life
  - May also be achieved by implementation of multiple stages of filtration, where suitable

Assuring Maintenance of Slurry PSD: Retention *vs.* Transmittance



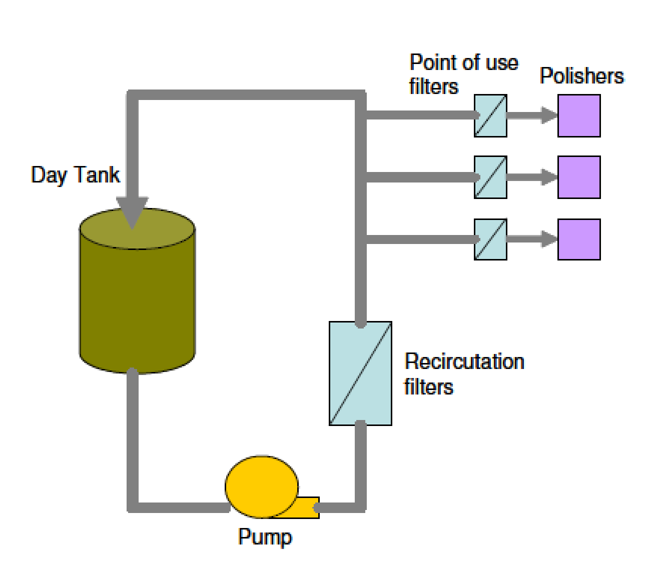


Sample Filter	Median Particle Size [µm]		Solids Concentration [wt%]	
	Raw	Filtered	Raw	Filtered
0.1 µm Pall Ultipor® GF-HV Filter	0.077	0.077	12.0	12.0
0.3 µm Pall Profile® II Filter	0.078	0.078	12.8	12.8

AccuSizer® 780 results (top) show removal of large particles from an actual HDD CMP colloidal silica slurry using two typical filters intended for dispersions, while finer PSD measurement and total solids evaluation (bottom) show maintenance of PSD and solids content

Applying Filtration to HDD CMP

- Filtration can remove oversized particles from slurries various HDD CMP applications:
  - 1st and 2nd stage polishing of NiP on Al/Mg substrates
  - 1st and 2nd stage polishing of glass substrates
  - Planarization at various levels in thin film heads
- Filter selection depends on several factors including slurry type, abrasive particle size, sensitivity of process to defects of a specific size, filter life considerations, *etc.*
- Filtration is often applied in recirculation loops, then again at the point of use (POU) at polishing tools *(above right*).
  - Coarser filtration is possible on loops due to increased likelihood of capture in multi-pass operation



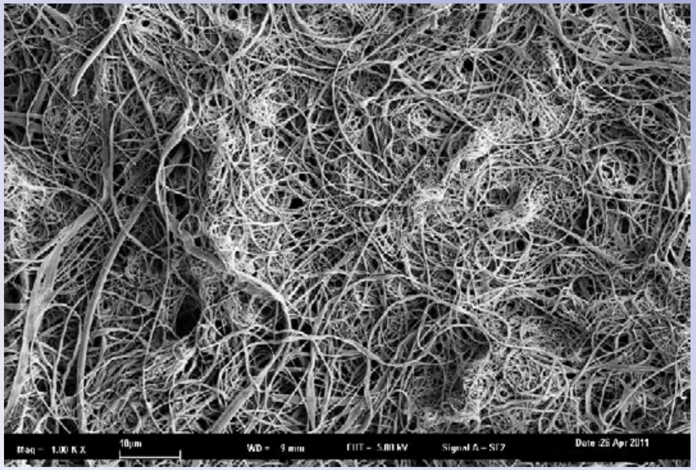
Schematic of distribution system for CMP slurry

Examples of Filter Usage in the Various HDD CMP Applications

- Thin film head CMP processes:
  - Depth, or depth/pleated, melt-blown polypropylene, at a rating of 5 µm has been used on silica slurries with MPD~150 nm
- 1st stage glass:
  - Generally coarse (> 20 µm) depth, or depth/pleated, melt-blown polypropylene has been used on ceria-based slurry with MPD ~1 µm
- 2nd stage glass:
  - Depth, melt-blown polypropylene at a rating of 1 µm has been used on silica slurry
- 1st stage NiP
  - Very coarse (essentially screens) may be used on alumina slurries
- 2nd stage NiP
  - Fine (0.45 µm, 0.1 µm) resin bonded glass fiber or fine (≤ 0.5 µm) depth, melt blown polypropylene have been used at POU on silica slurries with MPD < 100 nm (*e.g.*, "active" particle sizes of 20 – 80 nm), with depth melt blown polypropylene rated at 1 µm for loop filtration
    - *Our experience is that this application uses the finest filtration*

Selecting an Appropriate Filter for HDD CMP Slurry Filtration—*Focus on Pall Ultipor® GF-HV Product for 2nd Stage NiP*

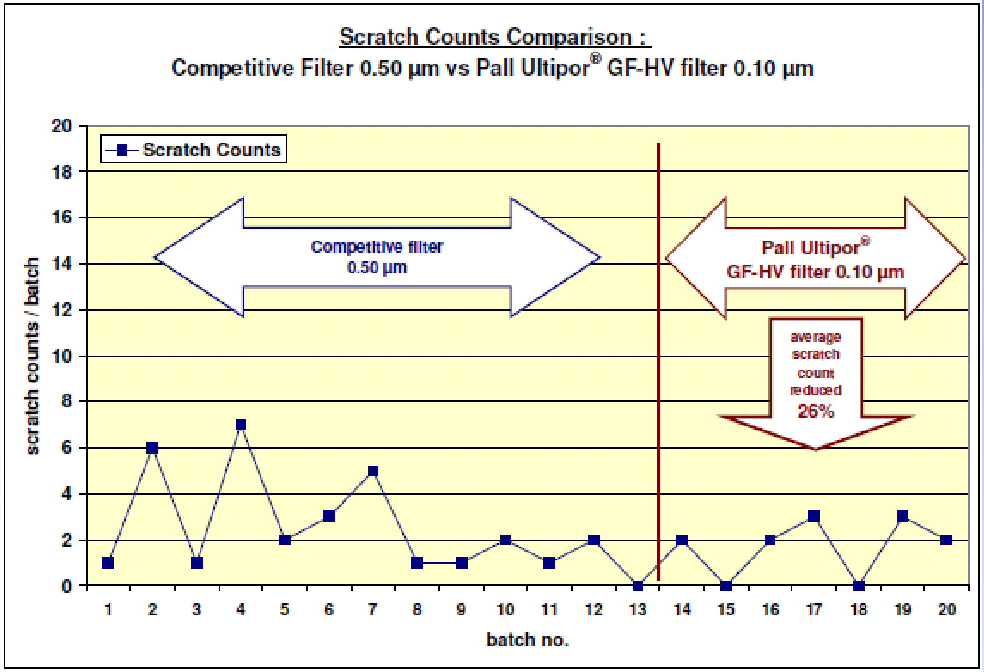
- Glass fiber filter medium structure in this product exhibits both desirable retention of oversized particles, and transmittance of active particles
  - Facilitated by the fiber morphology, fine fiber diameter, and high voids volume
  - Available in various submicron grades as fine as 0.1 µm (100 nm), which is coming to be a necessity based on abrasive particles as fine as 20 nm
- Optimized pleat structure and support material for low pressure drop even with high solids / high viscosity dispersions
- Demonstrated defect reduction in actual HDD CMP slurry application testing
  - Multiple positive field results for second stage NiP polishing with this product



Scanning electron microscopic image of unused filter medium from Ultipor GF-HV filter

Achieving Defect Reduction via Filtration: Real World Example

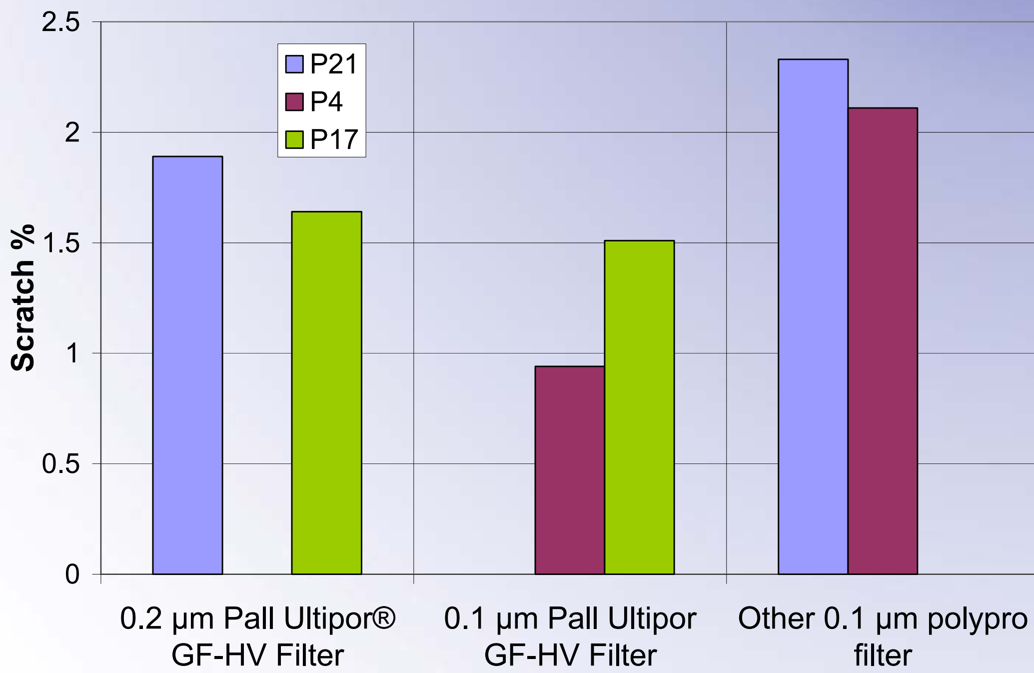
- CMP process:
  - NiP on Al/Mg (2nd stage)
- Slurry type:
  - Colloidal silica
- Working particle size:
  - ~ 80 nm
- Filtration types employed:
  - 0.1 µm glass fiber (Pall)
  - 0.5 µm polypro (non-Pall)
- Mode:
  - Point of use



Approximately 26% defect reduction observed in using 0.1 µm glass fiber type of filter designed for use in dispersions, compared to 0.5 µm filter of different construction

Additional Example with 0.1 µm Filtration for 2nd Stage NiP Polishing

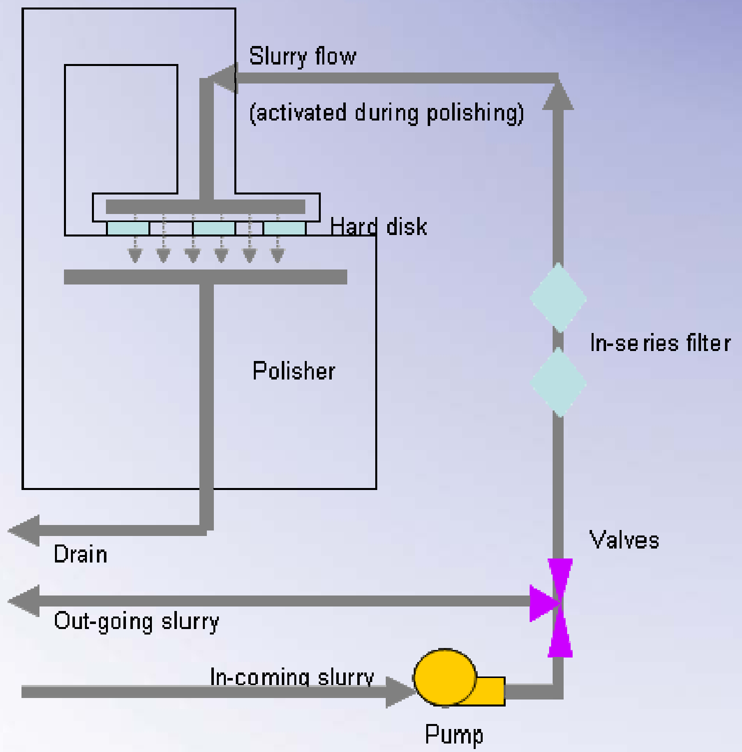
- CMP process:
  - NiP on Al/Mg (2nd stage)
- Slurry type:
  - Colloidal silica
- Filtration types employed:
  - 0.1 µm glass fiber (Pall)
  - 0.2 µm glass fiber (Pall)
  - 0.1 µm polypro (non-Pall)
- Mode:
  - Point of use



Scratch reject % reduced significantly with either 0.1 or 0.2 µm versions of Pall Ultipor GF-HV filter as compared to one type of 0.1 µm rated melt blown polypropylene pleated depth filter

Maintenance of Filter Performance Upon a Change in Filter Configuration

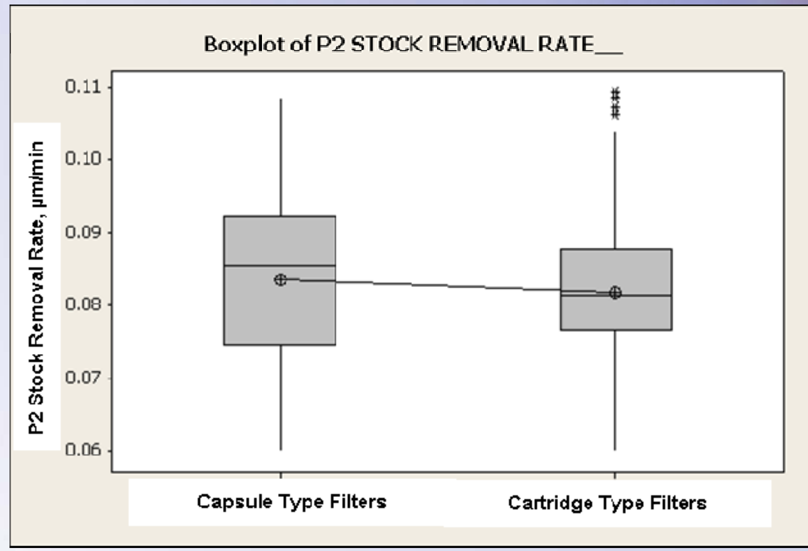
- Filter performance evaluated under a change of configuration from capsules to cartridges in housings
  - Capsule is compact and convenient, but limits available filtration area, increasing initial ΔP and lessening filter life
  - Using equivalent filters in housings can improve life, but is performance maintained?
- Testing conducted using Pall Ultipor GF-HV filters rated 1 µm ⇨ 0.45 µm in series with silica slurry possessing active particles @ < 50 nm
- Performance characteristics evaluated included:
  - Polishing rate
  - Defect level
  - Filter life

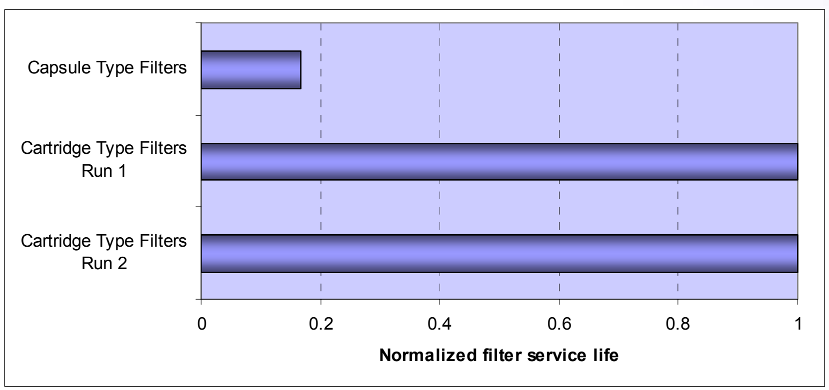


Schematic of system involved in testing of HDD CMP slurry filtration

Results of Evaluation of HDD CMP Slurry Filter in Cartridge *vs.* Capsule Style

- Equivalent polishing rate *(at right)* shows slurry characteristics have not changed
- Normalized failure rate shown to improve with cartridge style filter *vs.* capsule (*bottom right*)
- Filter life increased six-fold using cartridge style of filter (*below*)





		Capsule Type Filters	Cartridge Type Filters
Normalized Scratch failure rate results	Using AOI	1	0.75
	Using OSA	1	0.80
	Visual check for One line scratch	1	0.80
	Visual check for Micro-scratch	1	0.95
	Number of hard disks scanned	325	1516

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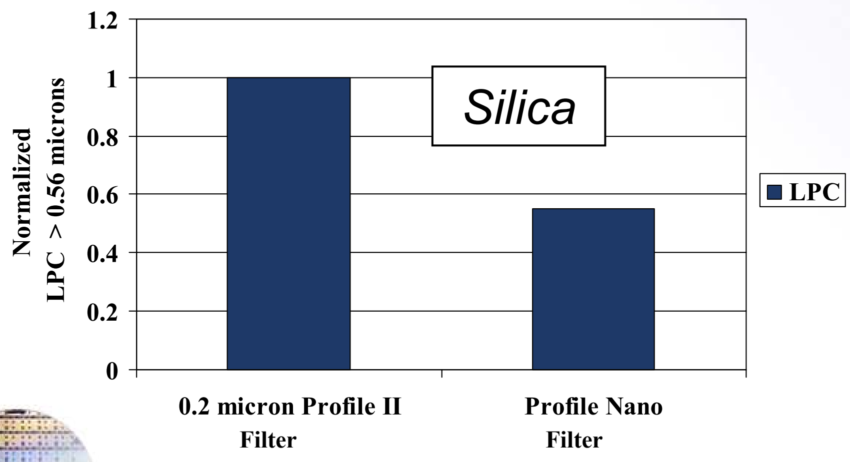
Future Needs and Directions in Improved CMP Slurry Filtration

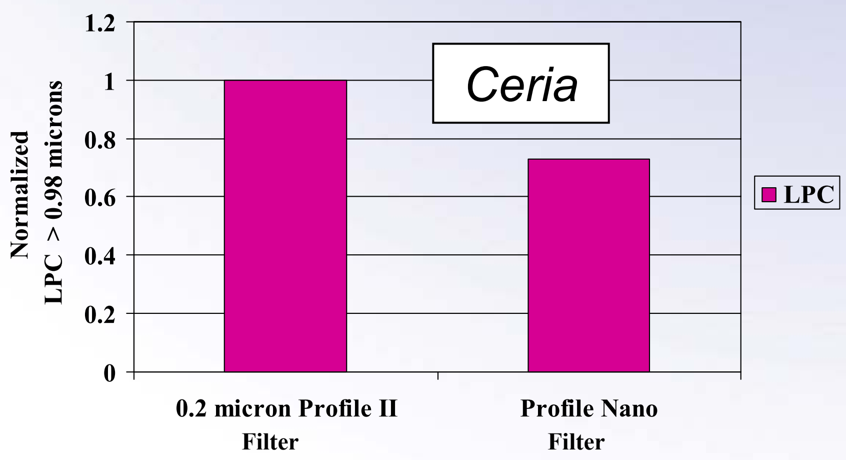
- Next generation filtration needs to address smaller “large” particles and agglomerates in CMP slurry
  - Use of finer melt-blown depth filtration could best address the complex problem of requiring retention to lower levels while also addressing transmittance and filter life
- Slurry nature (abrasives and chemistry) are evolving so filtration has to evolve
  - Could involve filters tailored to specific particle types or to specific chemistries
- Slurry cost (especially for ceria) could elevate the need to consider slurry reuse / recycling
  - This could be addressed via crossflow filtration or combinations of crossflow and dead-end filtration along with other steps.

Some Approaches for Addressing Future HDD CMP Needs

- Finer Melt-Blown Polypro Depth: Pall Profile® Nano filtration
  - Continues progression from 0.3 µm ⇨0.2 µm ⇨ < 0.2 µm
  - Product development has gone beyond "simply" producing finer fibers to addressing construction in greater depth
  - Trials expected in near future on 2nd stage NiP with SiO_2

Large particle count results for filtration of actual CMP slurries by Pall Profile II filter rated 0.2 micron and by Pall Profile Nano filter:





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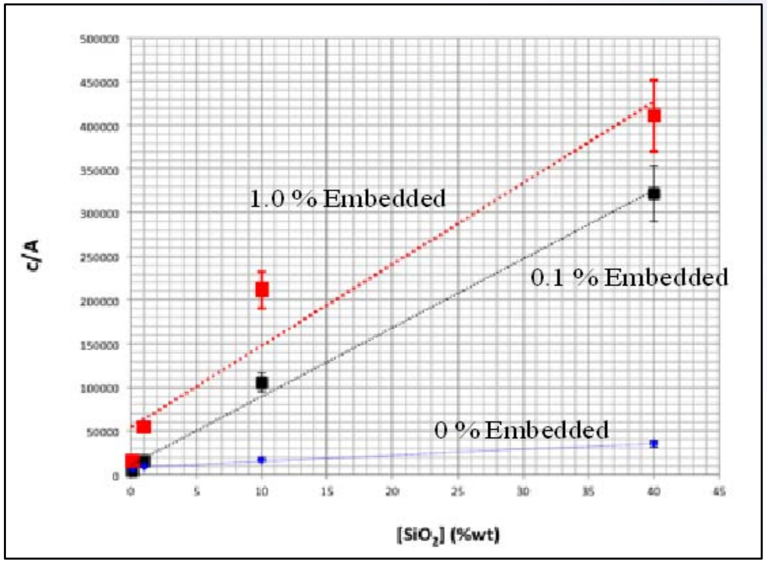
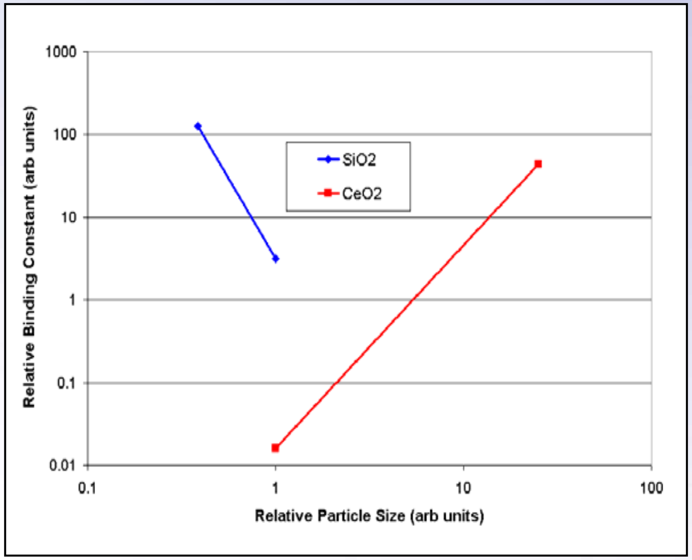
Some Approaches for Addressing Future HDD CMP Needs, *cont.*

- Investigation of the particle-filtration medium interaction
  - Continuing studies conducted in conjunction with academia using infrared spectroscopic and QCM to evaluate filtration medium behavior at the molecular level
    - Originally presented at ICPT 2011; new results to be presented at ICPT 2012
  - Results to date show that abrasive type (*e.g.* SiO_2 *vs.* CeO_2) and filter state (degree of loading) have an impact on surface interactions and ultimately filter behavior (and development)



Relative binding of silica to polypro film containing silica as model of partially loaded medium



Relative binding behavior of silica and ceria, each of two sizes, on polypro film

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Some Approaches for Addressing Future HDD CMP Needs, *cont.*

- Recycling of Ceria / Rare Earth Oxide Slurries via Pall crossflow filtration options
  - Initial testing using a ceramic module (Pall Membralox® product) has shown it to be effective in concentrating rare earth oxide slurry
  - Testing continuing on evaluating PVDF hollow fiber crossflow filtration for concentrating ceria slurry
    - Suitably rated module identified and initial testing completed
    - Currently optimizing parameters to achieve best performance