



A multi-step approach to developing filtration solutions for 22nm processes and beyond

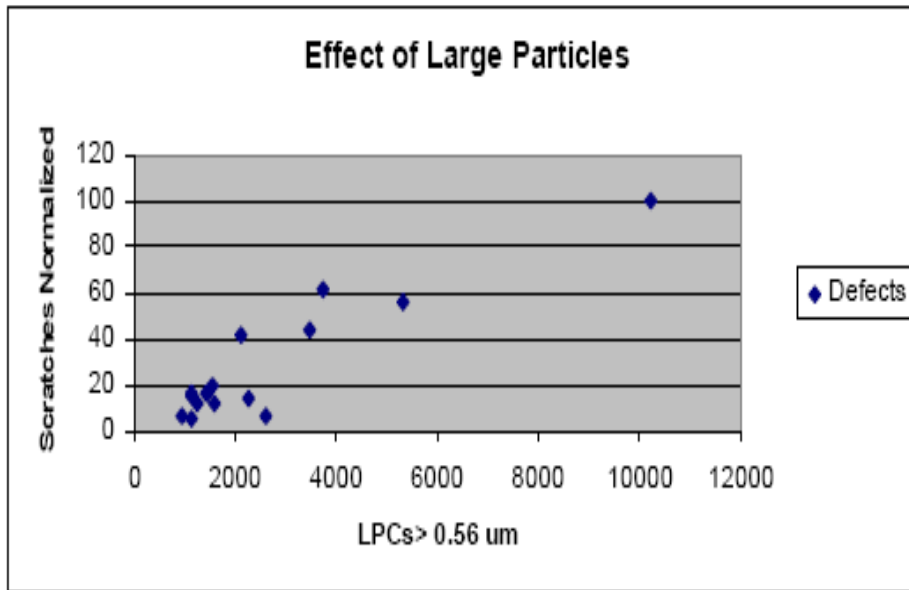
***Patrick Levy
Pall Corporation
May 11, 2011***

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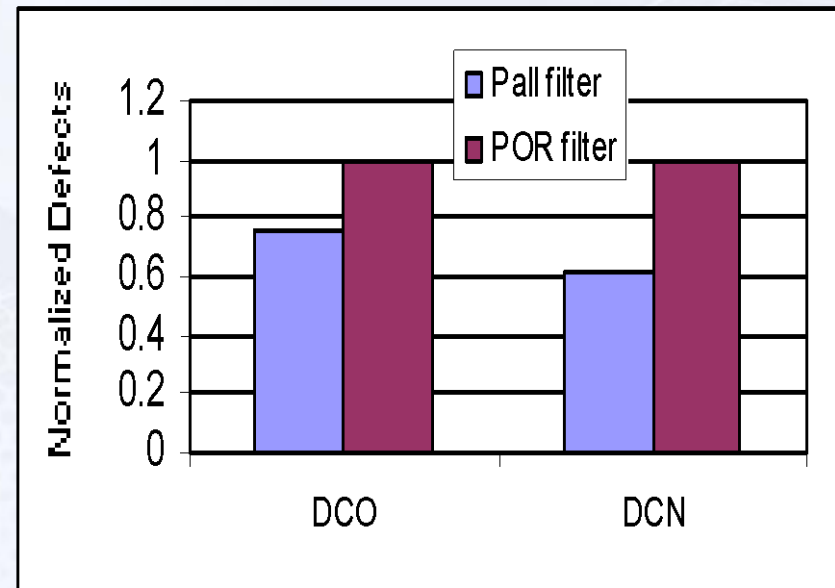
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Addressing CoO (earlier nodes) - Microscratch Reduction

Correlation between LPC's and Microscratches



Defectivity Improvements from ICPT 2005 Paper on ILD-CMP (Pall)



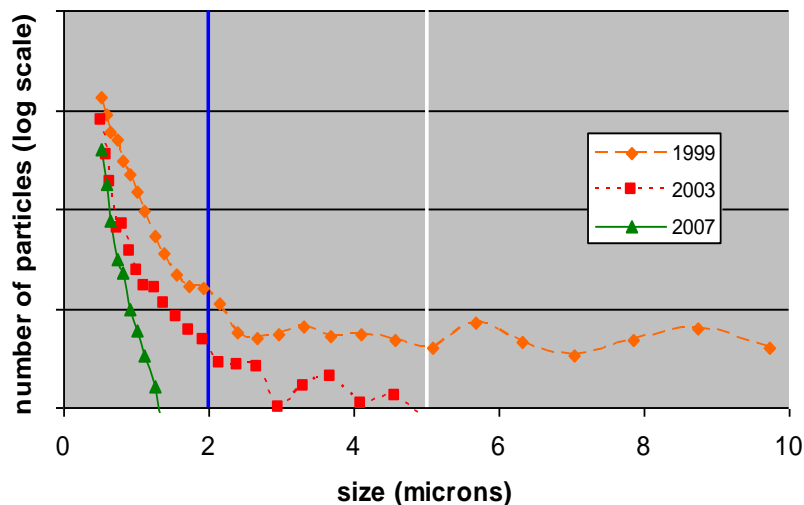
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The Driving Need for Better Filtration

Year of Production	2009	2010	2011	2012	2013	2014	2015	2015
Technology Node (nm)	50	45	40	36	32	28	25	22
Critical Particle Diameter (nm)	25	22.5	20	18	16	14	12.5	11

ITRS showing as feature size shrinks so does critical particle size

Evolution of LPC's for Fumed Silica Slurries



The oversized particles continue to decrease (especially >1μm)



Particle Size Distributions are getting smaller as the slurry abrasives change

New Filtration Requirements at 22nm

- **Earlier Processes**

- Reduce defects by using finer filtration
- Improve life by trading off efficiency

- **22nm Processes**

- Defectivity improvements still very important
- Fewer filter changeouts whenever possible
- Differential pressures becoming more of an issue
- Product should perform consistently within a process window no longer acceptable to simply meet a single performance claim (efficiency and liquid permeability)

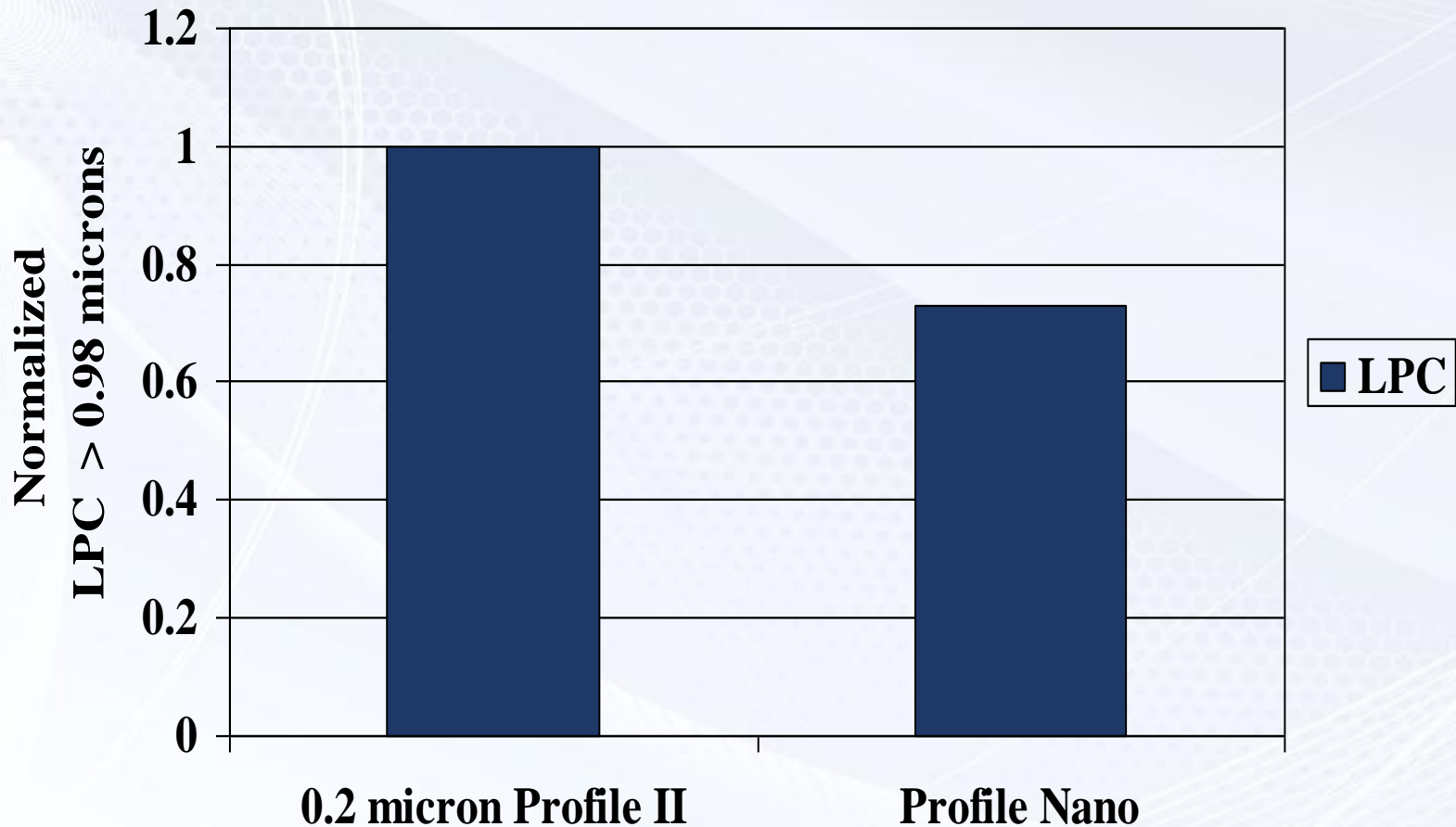
Defectivity Reduction - Profile^β Nano Filter

The New CMP Filter for 22 nm processes and beyond

- Specifically developed to classify ceria and low solids, colloidal silica slurries used in advanced CMP processes such as Shallow Trench Isolation (STI) and Barrier Copper
- Melt-blown nanofibers are produced using Pall's latest cutting-edge technology resulting in particle removal efficiencies of >99% at 200nm
- State of the art manufacturing process includes procedures and methods that provide greater process control resulting in superior product consistency and quality

Profile^β Nano Filter

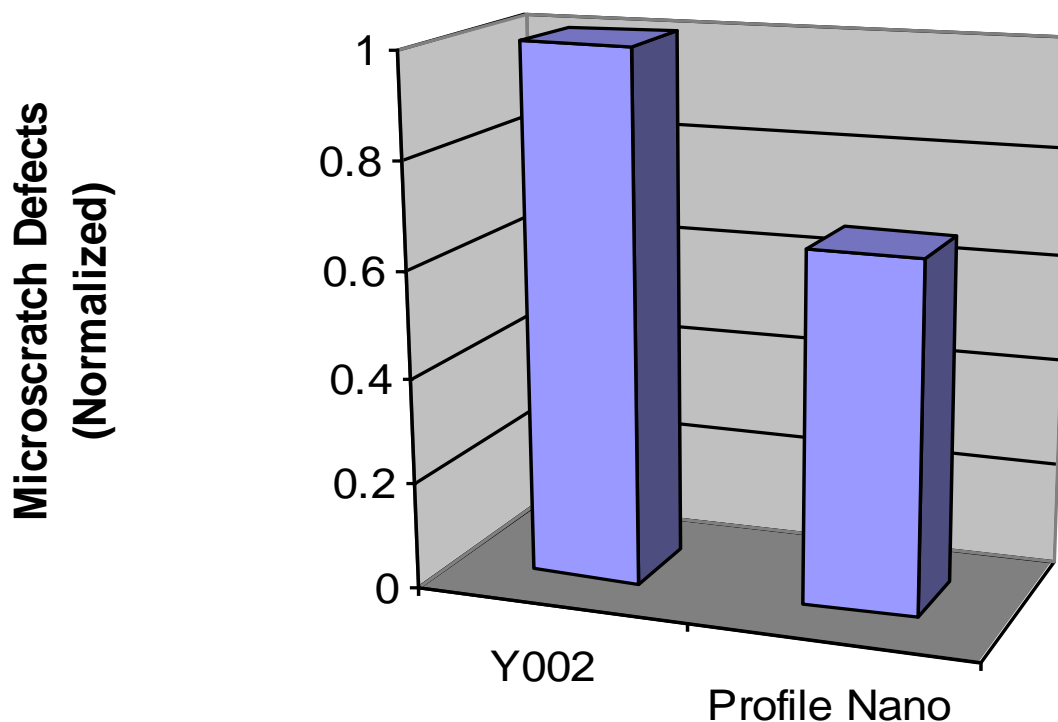
LPC results in a Ceria Slurry



Profile^β Nano Filter

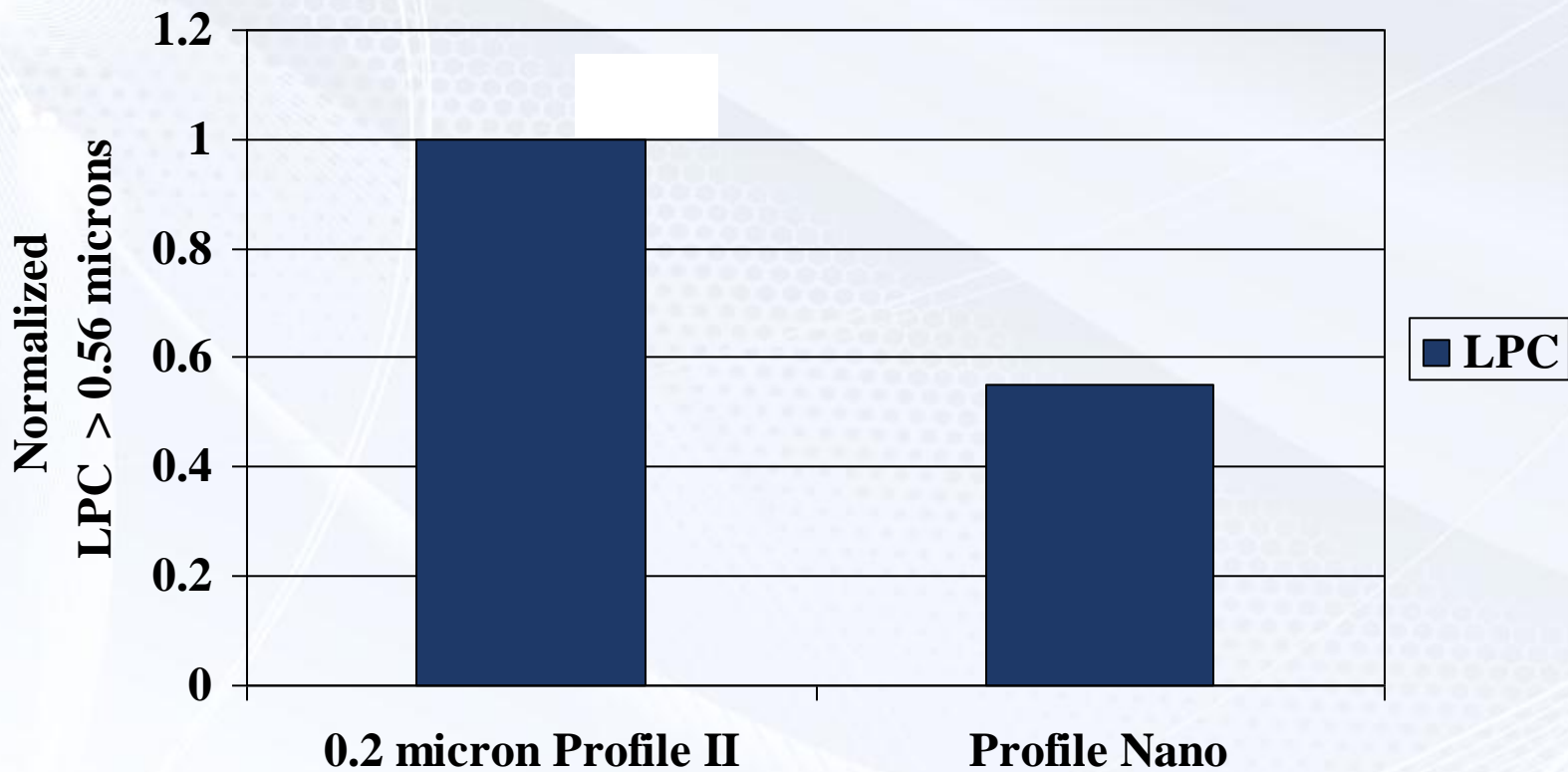
Microscratch Defectivity results in a Ceria Slurry

Defectivity Results with an STI slurry



Profile^β Nano Filter

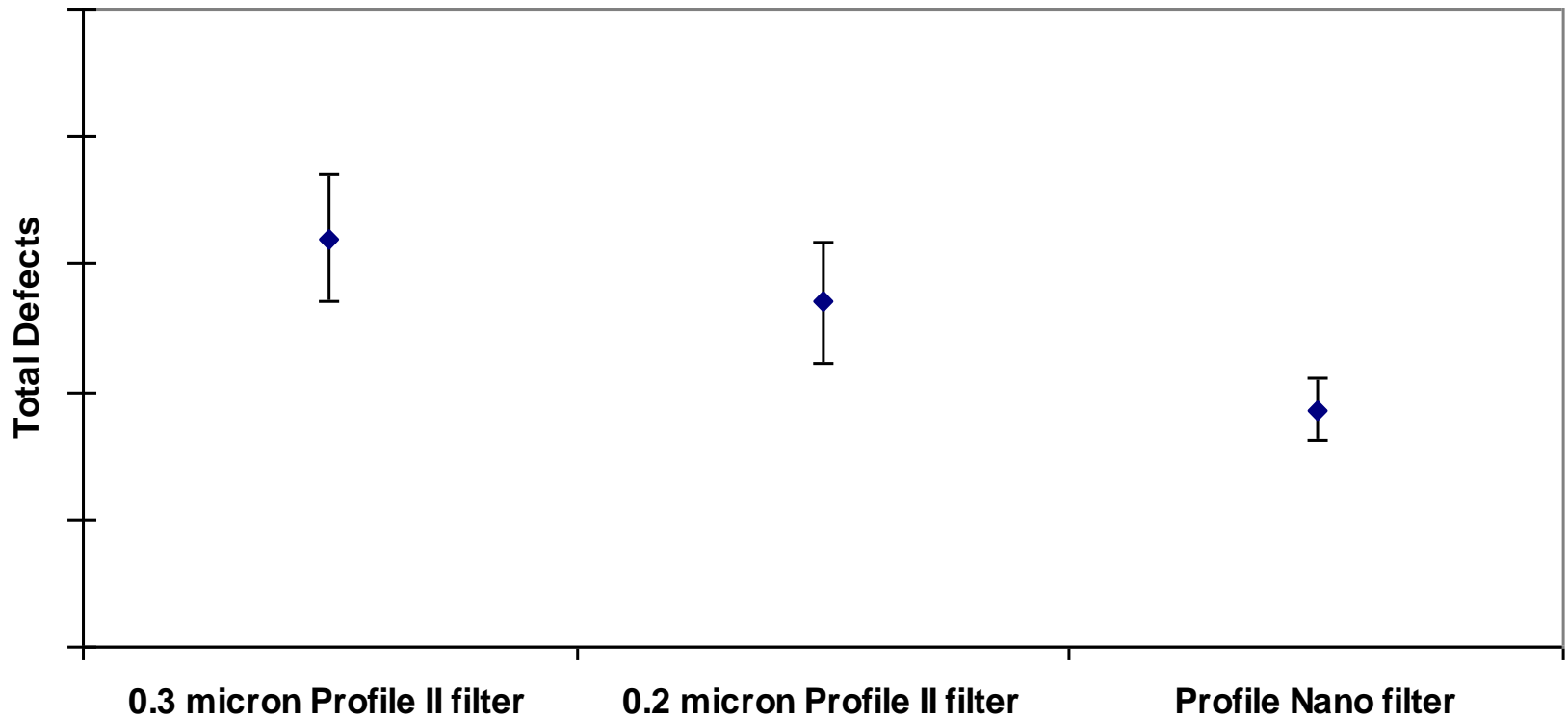
LPC results in a Colloidal Silica Slurry



Profile^β Nano Filter

Microscratch Defectivity results in a Colloidal Silica Slurry

Total CMP Defects on a Copper CMP Process



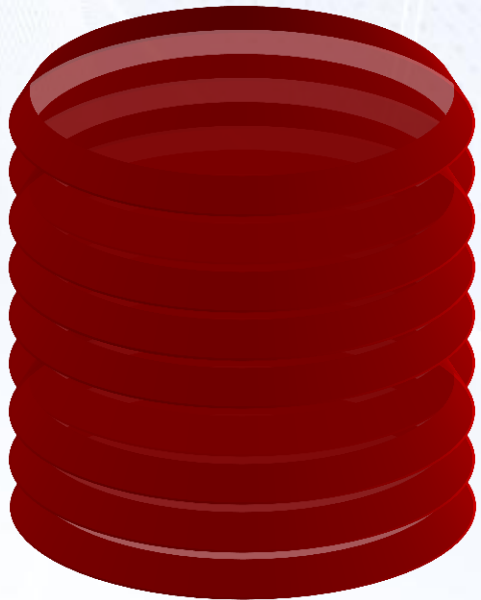
Profile^β Nano Filter – Product Consistency

- For previous meltblown products : Products were developed based upon overall cartridge level performance; quality measurements were performed at the cartridge level
- For Profile^β Nano filter: The product was developed to meet performance criteria of all key zones individually and collectively. It is manufactured to meet the key quality measurements of the individual media zones and the overall cartridge. The additional steps ensure consistent performance of the cartridge throughout the entire depth of the filter.

Profile^β Nano Filter – Product Consistency

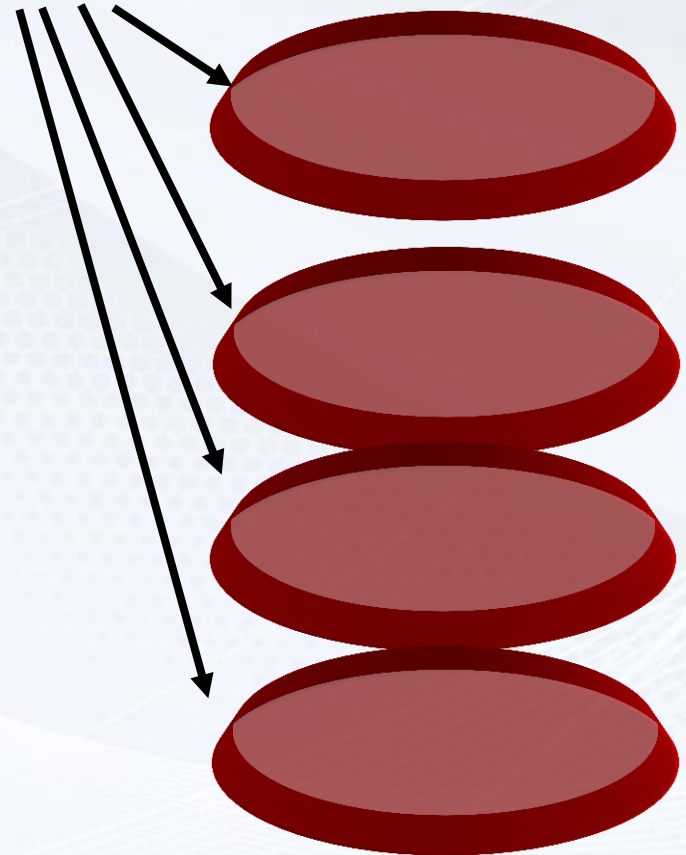
Standard Melt-blown Product used in CMP

Product Development and Quality Control based upon overall cartridge performance (using the entire depth of the filter)



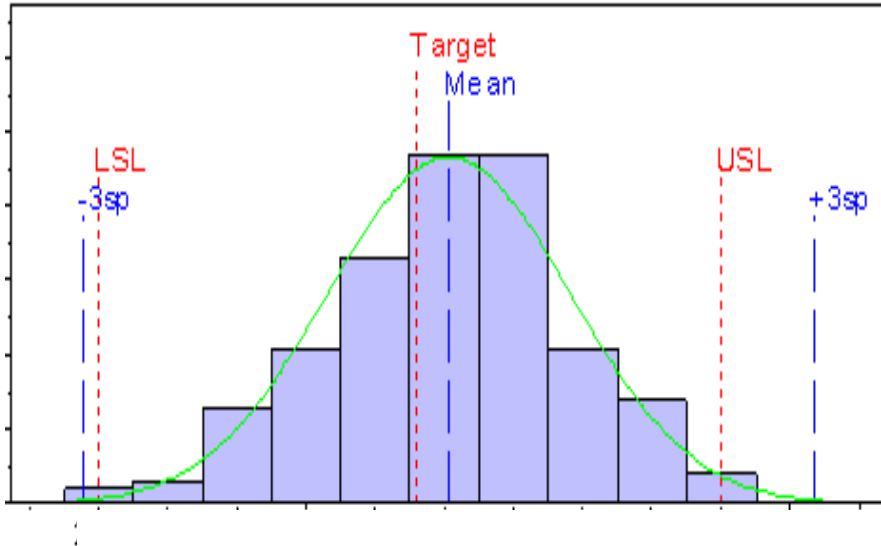
Profile^β Nano Filter

Product Development and Quality Control based upon the performance of individual zones and collectively

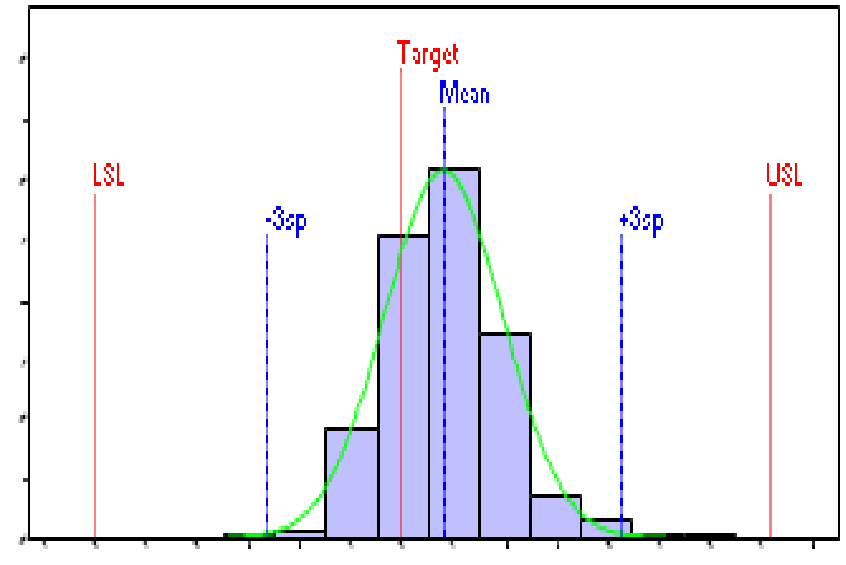


Improving Product Consistency in manufacturing

Achieving new quality standards for CMP filtration products



Typical manufacturing data for a legacy CMP product

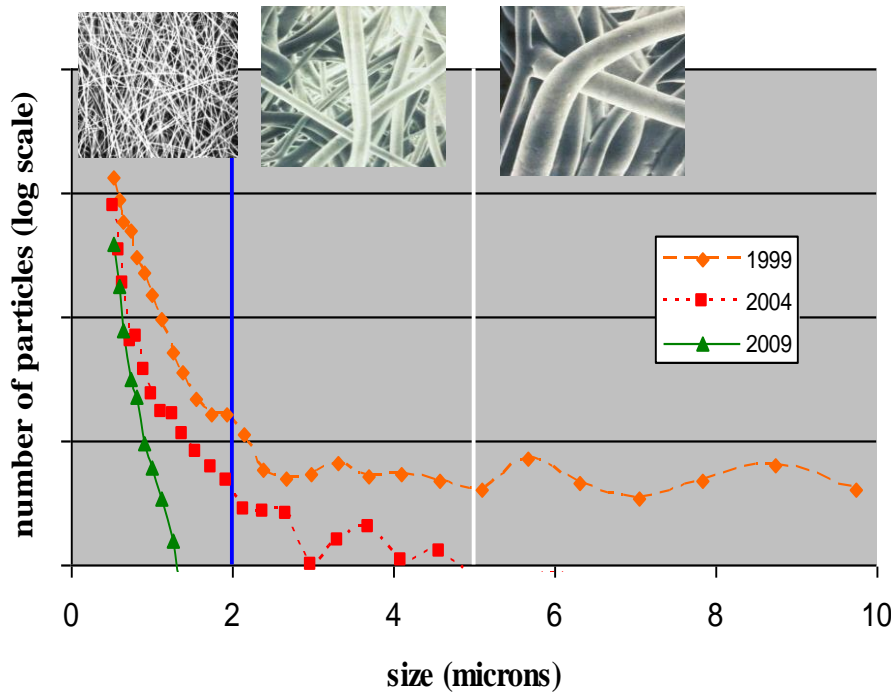


Manufacturing data for a recently developed CMP product

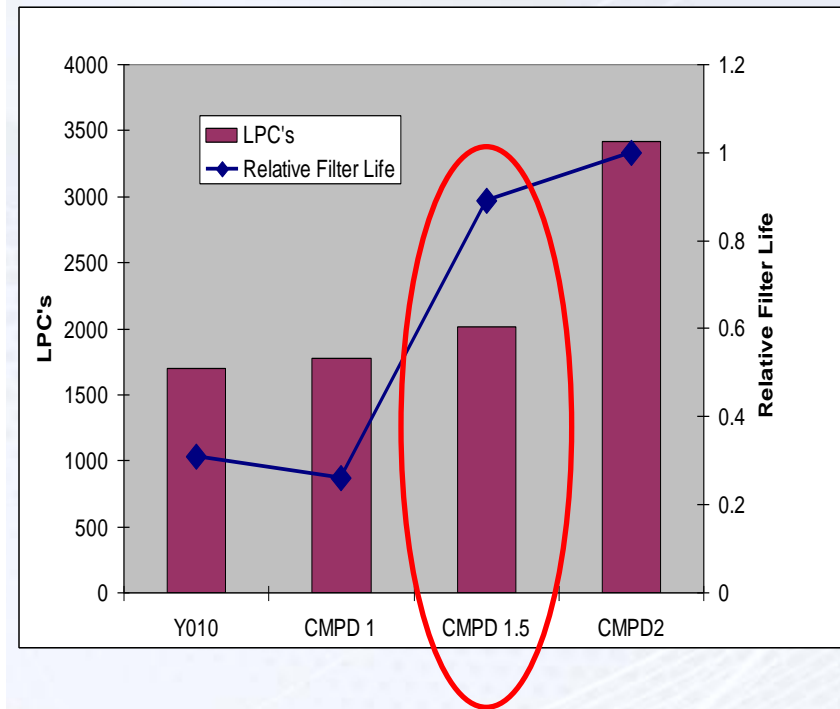
Improving Cost of Ownership through Cartridge Optimization

Development Based upon Slurry Characteristics

Evolution of typical LPC distributions for fumed silica CMP slurries



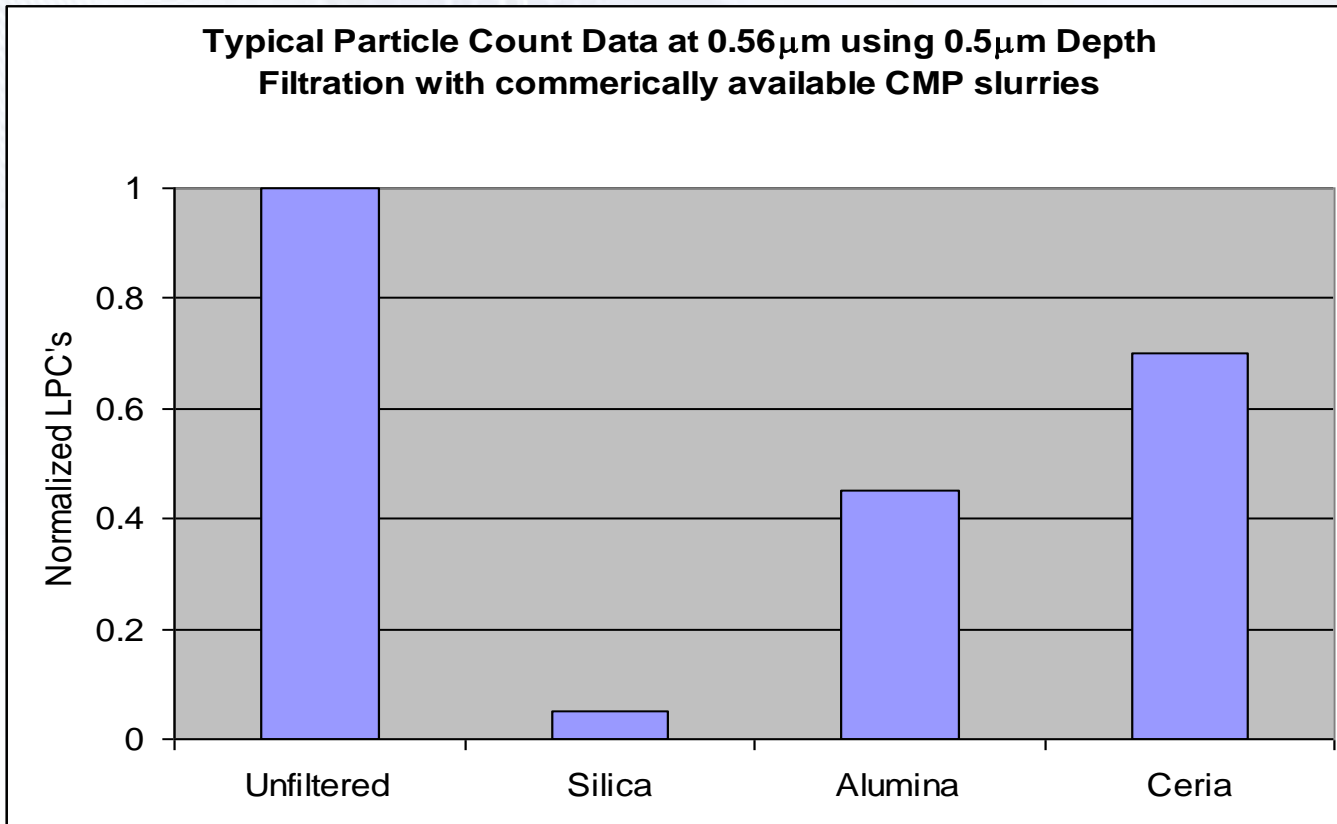
Filter efficiency and life testing with 12% solids fumed silica CMP slurry



***Improving CoO by developing products for CMP slurries based upon PSD**

Understanding Particle Retention of different abrasives

We have found that filter retention is very much dependent upon the type of slurry abrasive used. Therefore, it is very important to test filters with specific types of slurries to understand how they perform in certain applications.



- Empirically makes sense because we find filters will plug much more quickly with silica vs. ceria.
- Method used to size particles prevents comparison of measurements between different abrasives based upon existing techniques

Why is the retention of ceria particles so much less than silica?

Pall is actively exploring this topic by working with leading experts in the field (some findings)

- Analytical

- the particle sizing instrument assumes the abrasive particle being sized has the same refractive index as polystyrene – 1.59
- * Earlier work has shown that a silica particle with refractive index of 1.46 measured as 0.56 microns by the instrument was in fact 0.84 microns
- Ceria has a refractive index of 2.3 indicating it would actually be much smaller than the 0.56 micron measured

- Physical

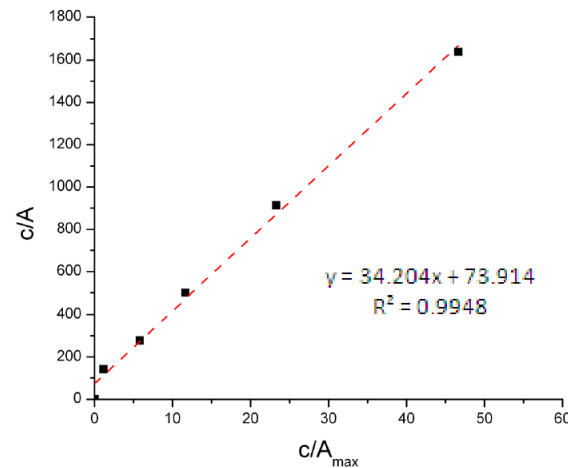
- does the density of ceria have an effect
- some recent work we have done exploring abrasive/filtration medium interactions has shown that silica will tend to adsorb to polypropylene media but ceria does not

* *Remsen, et al, Cabot Microelectronics (2005)*

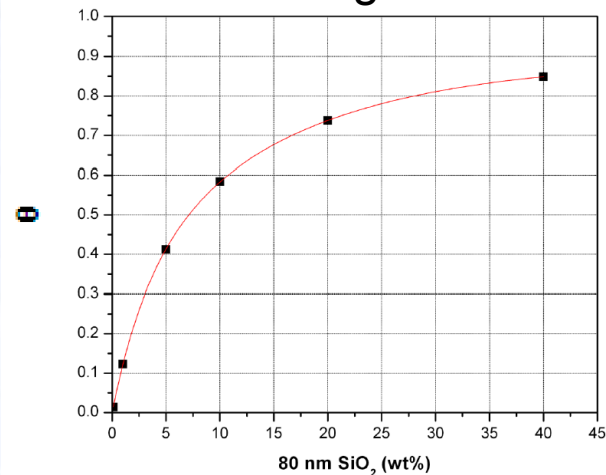
Exploring Abrasive/Filtration Medium Interactions

- ◆ Filtration medium is modeled as a film in contact with slurry containing abrasive
- ◆ Spectroscopic technique found to be effective showing differences in absorption vs. solids loading in slurry
- ◆ Results shown for testing with silica (SiO_2) as model abrasive

Linear adsorption isotherm

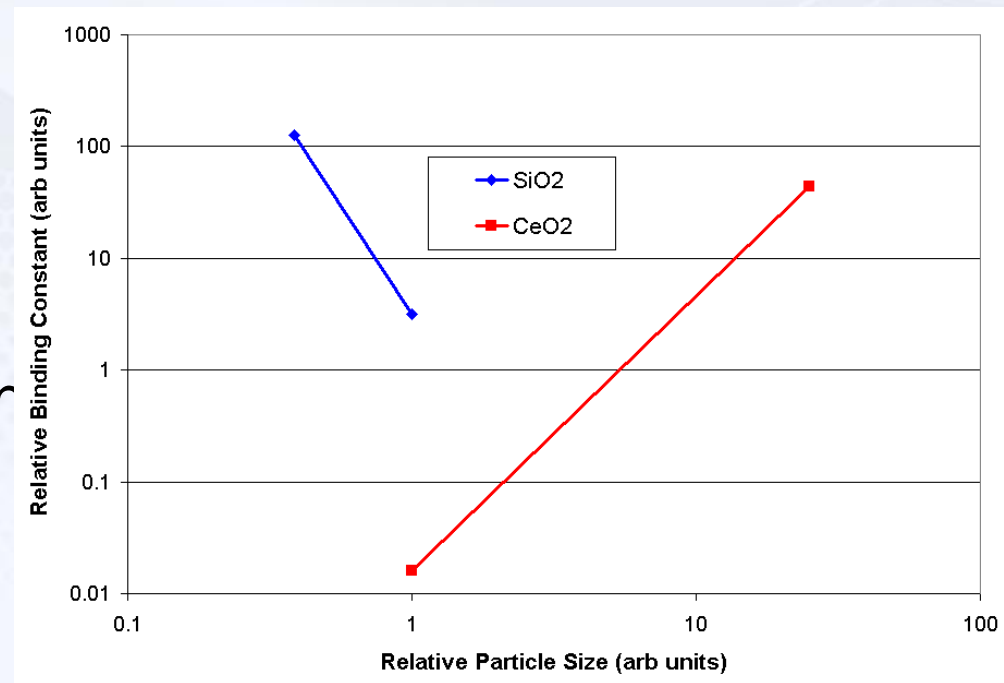


Determination of degree of saturation (θ)



Interaction vs. Particle Size

- ◆ Testing has now been conducted using a few different abrasive types
- ◆ Results show clear difference in behavior among materials
- ◆ Particle size also a factor in the nature of interaction
- ◆ These findings are consistent with known filter behavior



Conclusions

- Developing finer filtration to address microscratch reduction continues to be a very important means of addressing cost of ownership issues related to CMP processes.
- The new challenges associated with 22nm processes has required the establishment of other initiatives to further optimize the development of filtration solutions.
- Improving filter life through cartridge optimization and manufacturing products within tighter specifications are two ways Pall is reducing customer CoO
- Preliminary results from our particle/filter medium interactions investigation is providing possible answers into the question of why slurries containing different abrasives filter so differently

Acknowledgements

- Dr. Patrick Connor – Pall Corporation
- Dr. Jason Keleher – Lewis University