IEEE SW Test Workshop
Semiconductor Wafer Test Workshop

Probe Card Cleaning Media Survey

Eric Hill, Josh Smith : : June 10, 2008

Special Thanks To:

international TEST SOLUTIONS

MIPOX
NANO-SURFACE TECHNOLOGY SOLUTIONS

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HIGH TECH PRODUCTS, INC.

3M

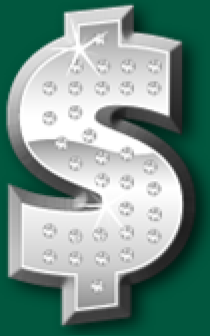
Outline

- Introduction
- Materials and Methods
- Results
- Conclusions
- Acknowledgments

Why Optimize Online Cleaning?

- Probing is a dirty business
- Cleaning probe tips keeps device yield up
  - Yield is money
- Time spent cleaning is lost test cell utilization
  - Test cell utilization is money
- Abrasive cleaning wears out probes
  - Replacing probe cards costs money

- Optimizing cleaning saves money!



SWTW-2007 Cleaning Tutorial Session

Selection Matrix "Eye Chart"

	Morphology		Mech.	Cantilevered Probe Tip Wear			Debris	Temp	Cantilevered			Vertical - Cobra			Advanced
Description	Surface	X-Sect.	Perform	Length	Diam.	Shape	Collect	Range	Flat	Radius	Semi	Flat	Wedge	Point	Contacts
Rigid Substrate					increase	flat	N	-50C to 125C	Lapping			Contact Supplier			Contact Supplier
Polyester Backed Lapping Film					increase	flat	N	-50C to 125C	Lapping						
Lapping Film on VHB Foam					increase	flat	N	?	Lapping						Contact Supplier
Large Cell Foam					sharpen	pointed	N	-30C to 130C				Contact Supplier			Contact Supplier
Unfilled Polymer					no change	no change	Y	-50C to 200C	Debris Only	Debris Only	Debris Only				Contact Supplier
Filled Polymer					no change	little change	Y	-50C to 200C	Debris Polish	Debris Polish	Debris Polish				Contact Supplier
Abrasive Layer Small Cell Foam					increase	flat	N	-??C to 130C							Contact Supplier
Polymer Layer on Lapping Film					increase	flat	Y	-50C to 125C	Debris Nugget						Contact Supplier

- Optimal on-line cleaning materials selection during wafer sort is a critical element of integrated chip manufacturing process
- Industry is requesting probe technology + cleaning solution
- Economic benefits of "educated" cleaning are best realized with high value devices and probe card technologies
  - Throughput and uptime improvements
  - Increased wafer yields
  - Extended probe card service life and performance

June 3-6, 2007 IEEE SW Test Workshop 48

Broz, et. al., SWTW-2007

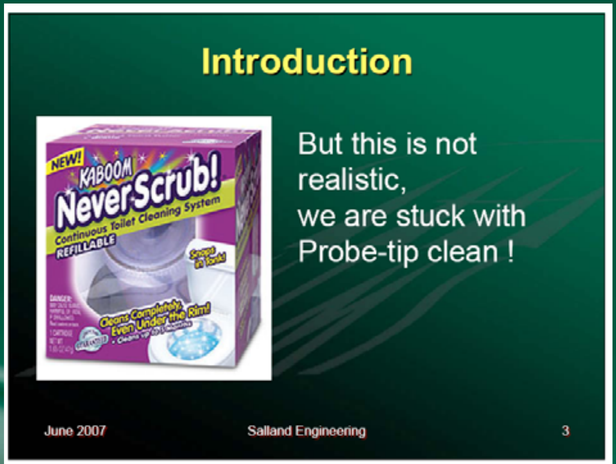
Cleaning Media Survey

- Wide variety of media available
- Previous surveys not targeted at Pyramid Probes

- Define consistent evaluation criteria
  - Mechanical criteria in Phase 1
  - Resistance testing in Phase 2
- Test commercially available abrasive media
  - 20 media
  - 4 suppliers
  - Rigid substrates and unfilled elastomers not considered
- Evaluate and rate media suitability for use with Pyramid Probes
- Search for the “ideal” medium

What is the “Ideal” Cleaning Medium?

- Removes adherent contamination from tips
- Non existent Tip Wear
- No particles generated by cleaning media
- No residue left on tips
- Media captures particles from membrane
- Cleaning action insensitive to overdrive



R. Marcelis, SWTW-2007

Measurement Summary (per cleaning medium)

- Measure Insertion/Extraction force

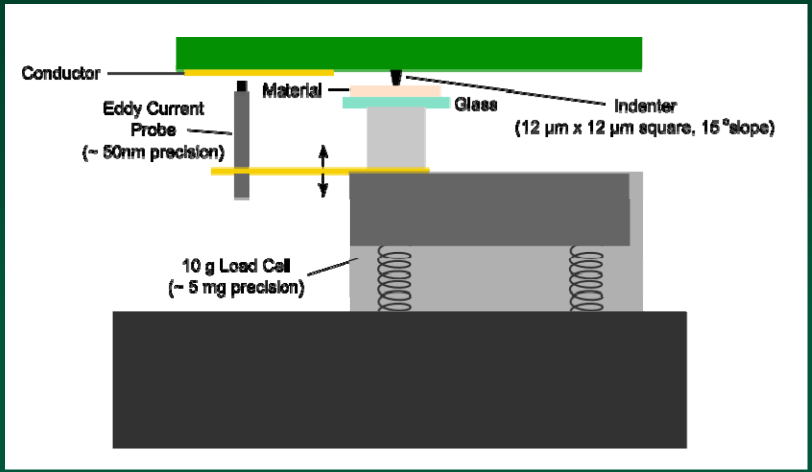
- Accelerated Wear Test

http://www.accretech.com

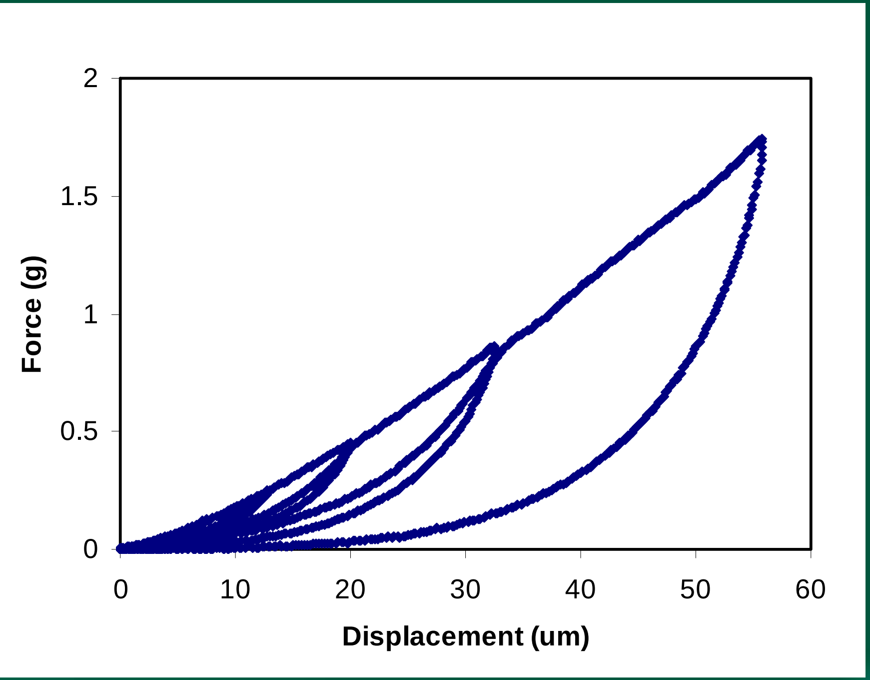
- SEM inspection

http://www.fei.com

Insertion/Extraction Force



Insertion Force
Measurement Setup



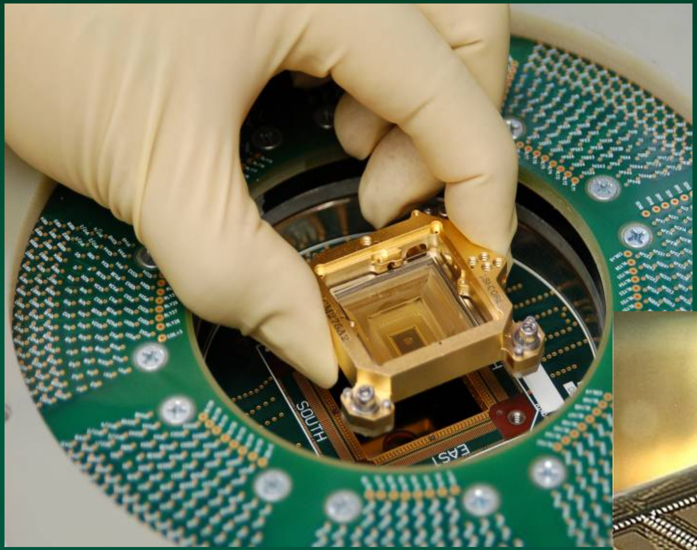
Typical insertion/extraction Curve

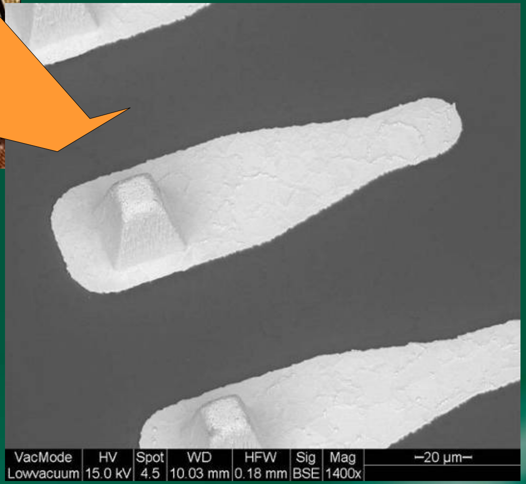
Accelerated Wear Test

- New Pyramid Probe card
- Cleaning touchdowns only
  - Vertical motion only
  - 100 microns cleaning overdrive
  - 50 micron step between touchdowns
  - No wafer touchdowns
- Touchdown intervals of:
  - 1k, 2k, 5k, 10k, 20k, 20k touchdowns (58k total)
- After each interval:
  - Measure Tip Height
  - Optical inspection
- SEM inspection after 58k touchdowns
  - Assess contamination

http://www.engin.umich.edu/

Pyramid Probe Card at a Glance

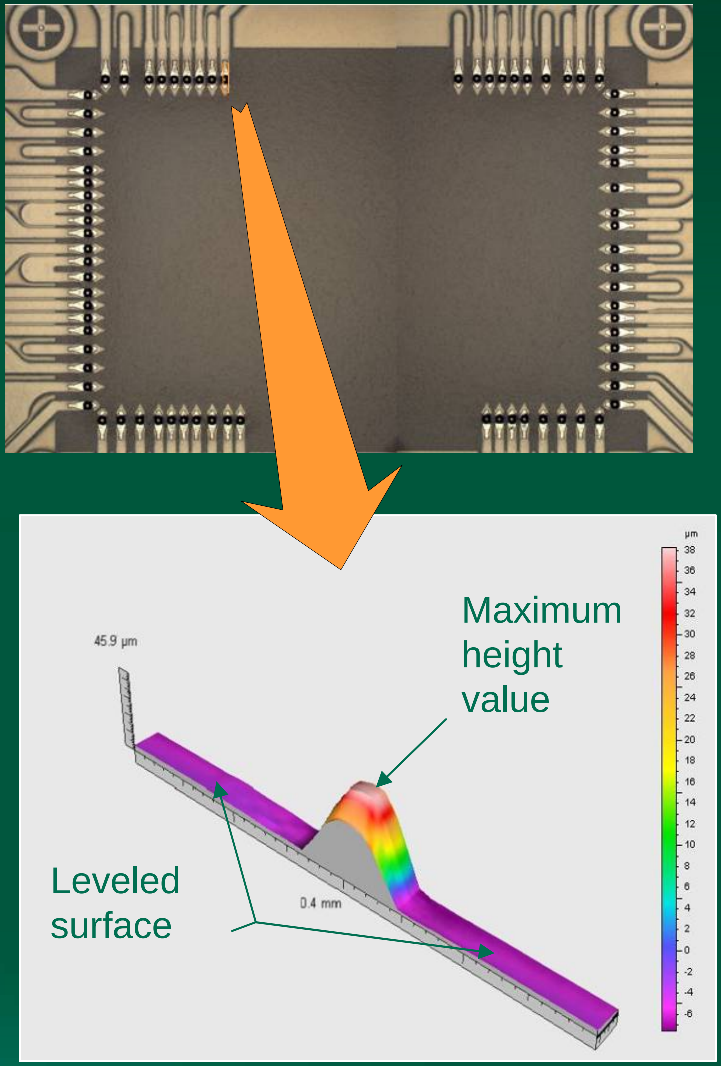




New probe card used for each medium's Accelerated Wear Test

Tip Height Measurement

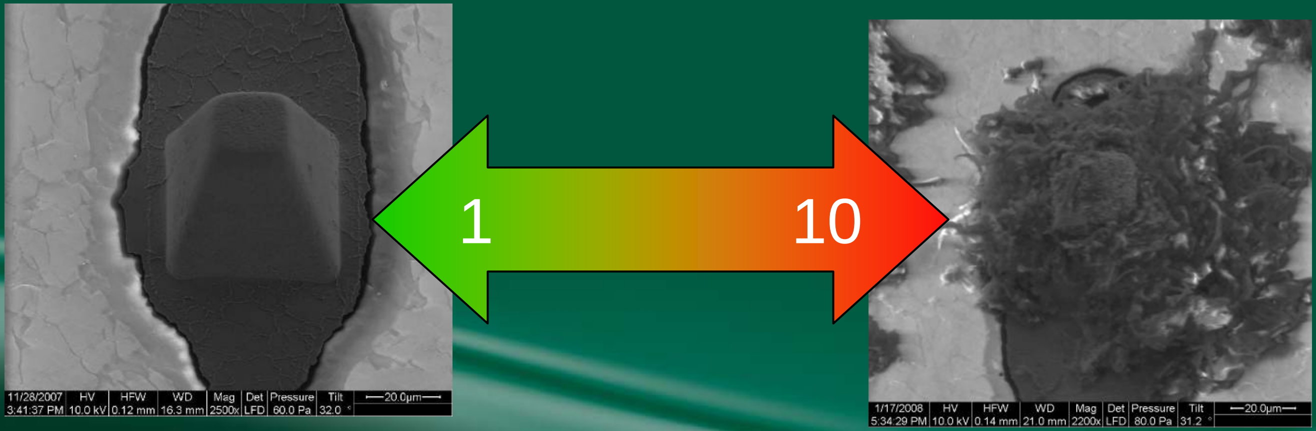
- Stylus profilometer
- 3D scan of region around tip
  - 5 scans per tip
  - 6 micron spacing between scans
- Record Total Indicated Runout (TIR) relative to local membrane surface
- Measurement accuracy of 0.5 microns or better
- Repeated for each tip



Quantifying contamination generated by cleaning process (C_{debris})

- Image tips after testing in SEM
- Qualitatively rank contamination
  - 1 = least, 10 = most
  - $R_{particle}$ = relative size of particles (1-10)
  - F_{memb} = frequency of debris on membrane (1-10)
  - F_{tip} = frequency of residue on tip (1-10)
- Weighted Debris Function

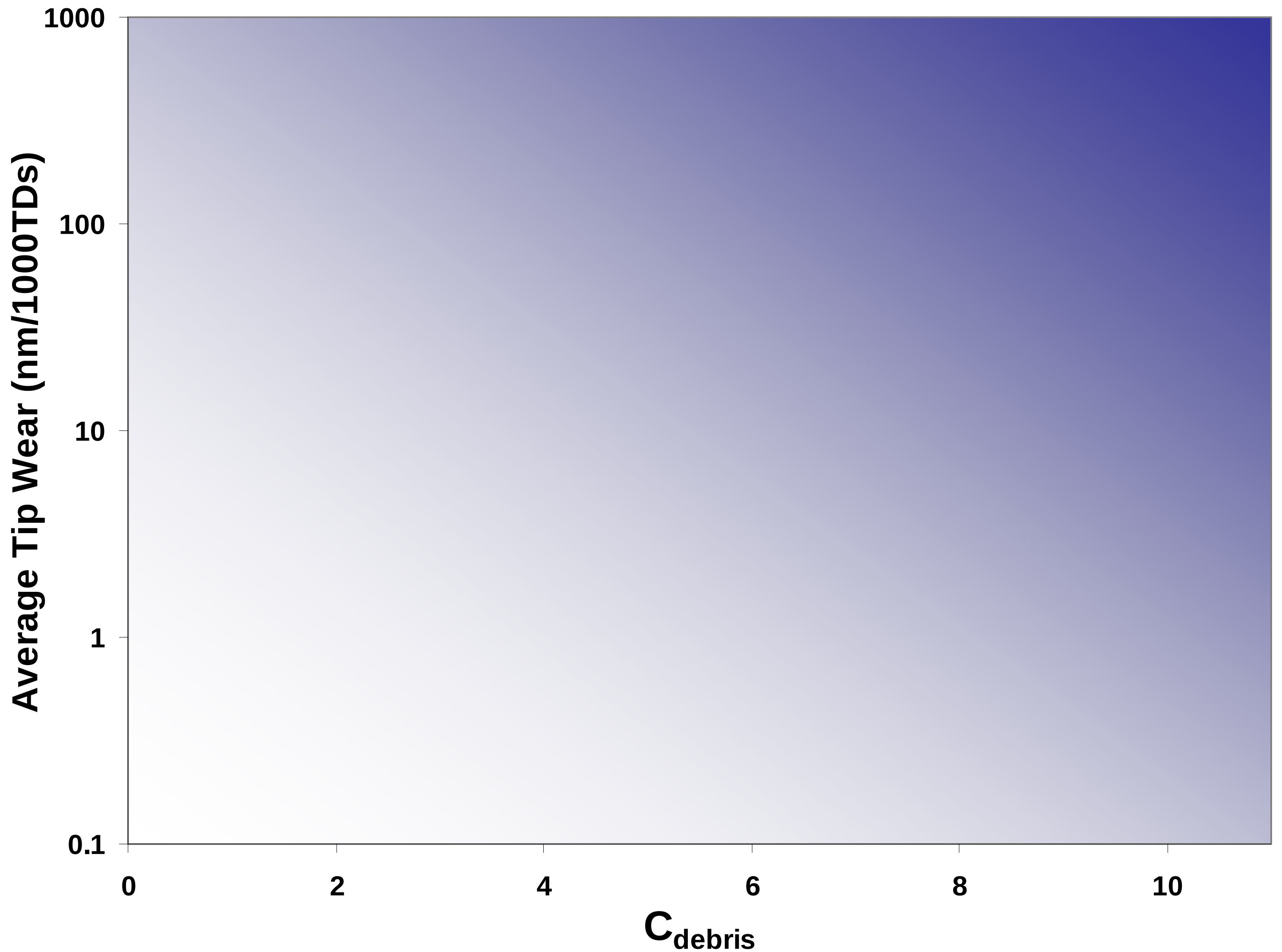
$$C_{debris} = [\ 0.7\ (R_{particle}) + 0.2\ (F_{memb}) + 0.1\ (F_{tip})]$$



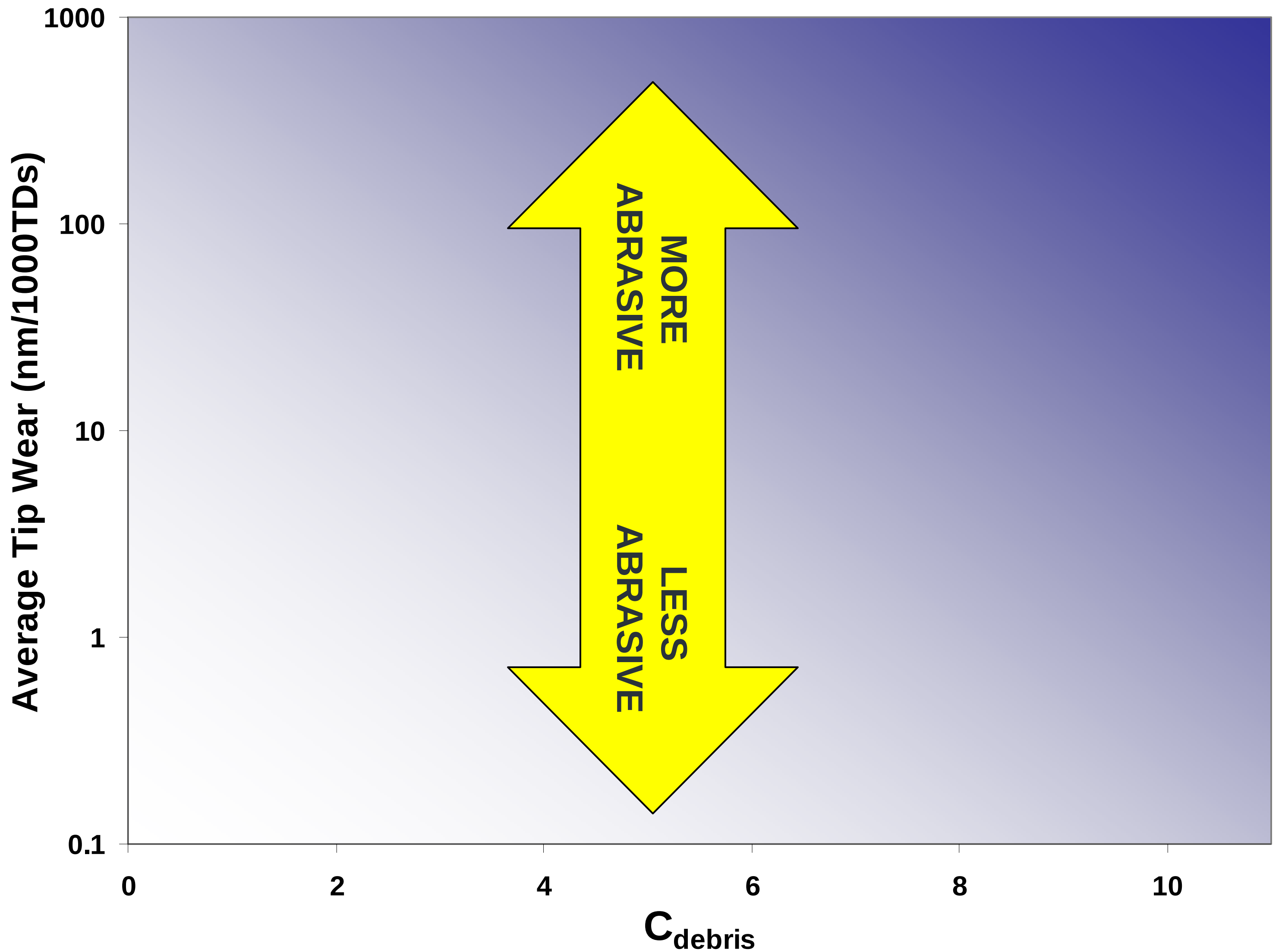
Full Results Summary

Manufacturer	Product	Type	C_{debris}	Single Tip Spring Rate (g/µm)	Wear Rate (nm/1k TDs)	Note
Allied High Tech Products	1 micron Type B	Lapping Film	10.0	1.09	305	Damaged Tips
Allied High Tech Products	6 micron Type B	Lapping Film	10.0	1.47	299	Damaged Tips
Allied High Tech Products	3 micron Type B	Lapping Film	10.0	1.45	128	Damaged Tips
MIPOX	GC6000-PF3	Soft-backed Lapping Film	6.0	0.21	66.5	Uneven Wear
ITS	Probe Lap 5084	Lapping Film	4.9	1.23	54.6	
3M	3M T-CL	Soft-backed Lapping Film	5.6	0.79	39.8	Uneven Wear
Allied High Tech Products	3 micron, acetone wash	Lapping Film	3.3	2.03	34.2	
Allied High Tech Products	3 micron	Lapping Film	6.9	2.16	29.9	
MIPOX	WA8000-SWE	Abrasive Coated Foam	3.6	0.19	28.8	
MIPOX	WA6000-SWE	Abrasive Coated Foam	2.7	0.30	23.6	
3M	266X – 1 micron	Lapping Film	3.7	2.79	15.5	
Allied High Tech Products	6 micron	Lapping Film	10.0	2.26	14.9	Extreme Debris
MIPOX	GC8000-PF3	Soft-backed Lapping Film	7.3	0.14	14.3	
3M	265X – 1 micron	Lapping Film	3.7	1.21	11.7	
MIPOX	1 micron	Lapping Film	6.9	2.27	2.6	
ITS	Probe Polish 150	Abrasive Loaded Elastomer	1.0	0.04	2.6	
ITS	Probe Polish 70	Abrasive Loaded Elastomer	2.8	0.01	1.5	
MIPOX	Si10000-PF3	Soft-backed Lapping Film	7.1	0.03	1.3	
ITS	Probe Polish 99/I	Abrasive Loaded Elastomer	1.0	0.01	0.6	
MIPOX	Si10000-SWE	Abrasive Coated Foam	2.8	0.18	0.5	

Accelerated Wear Results Graph



Accelerated Wear Results Graph



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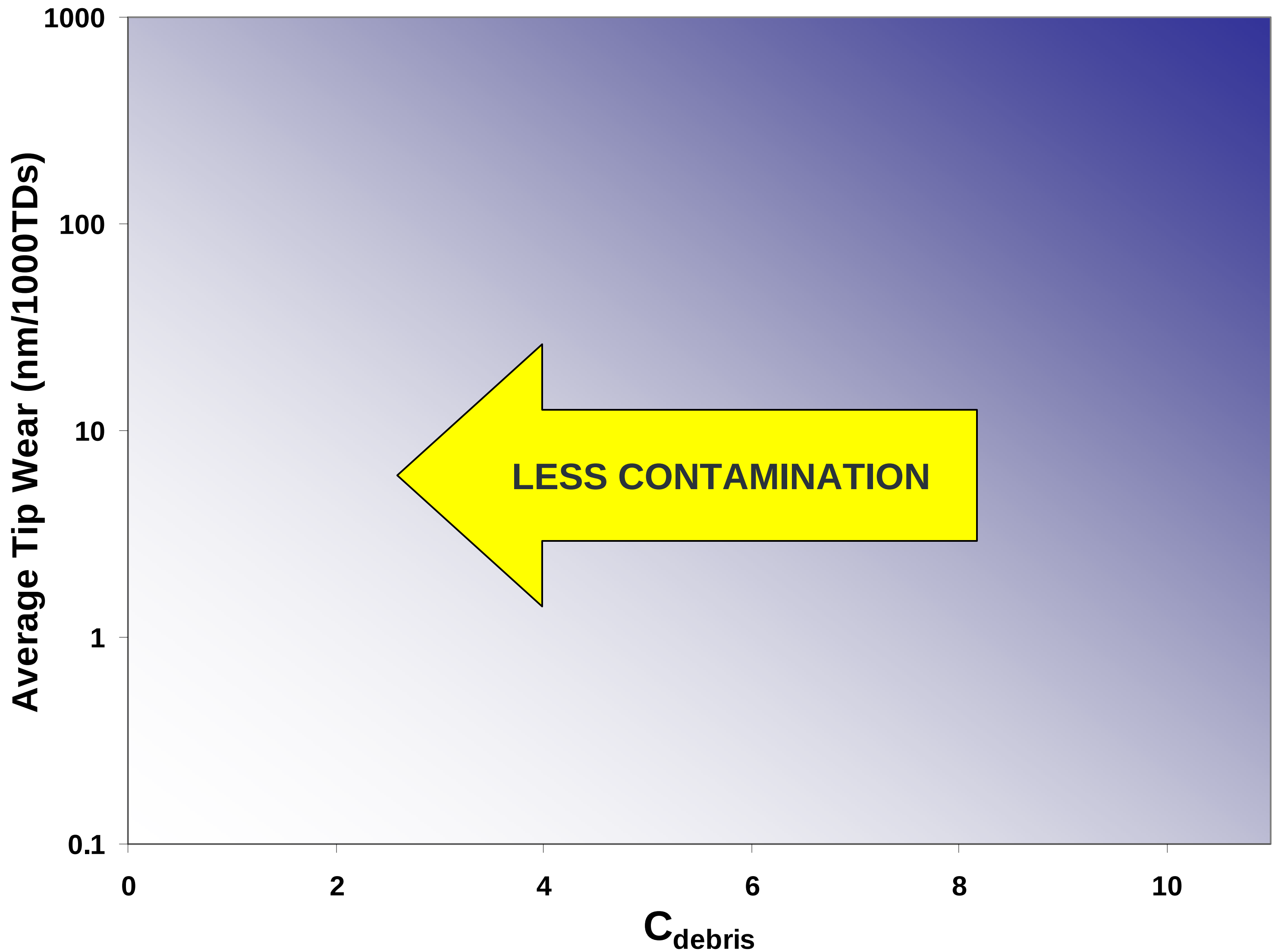
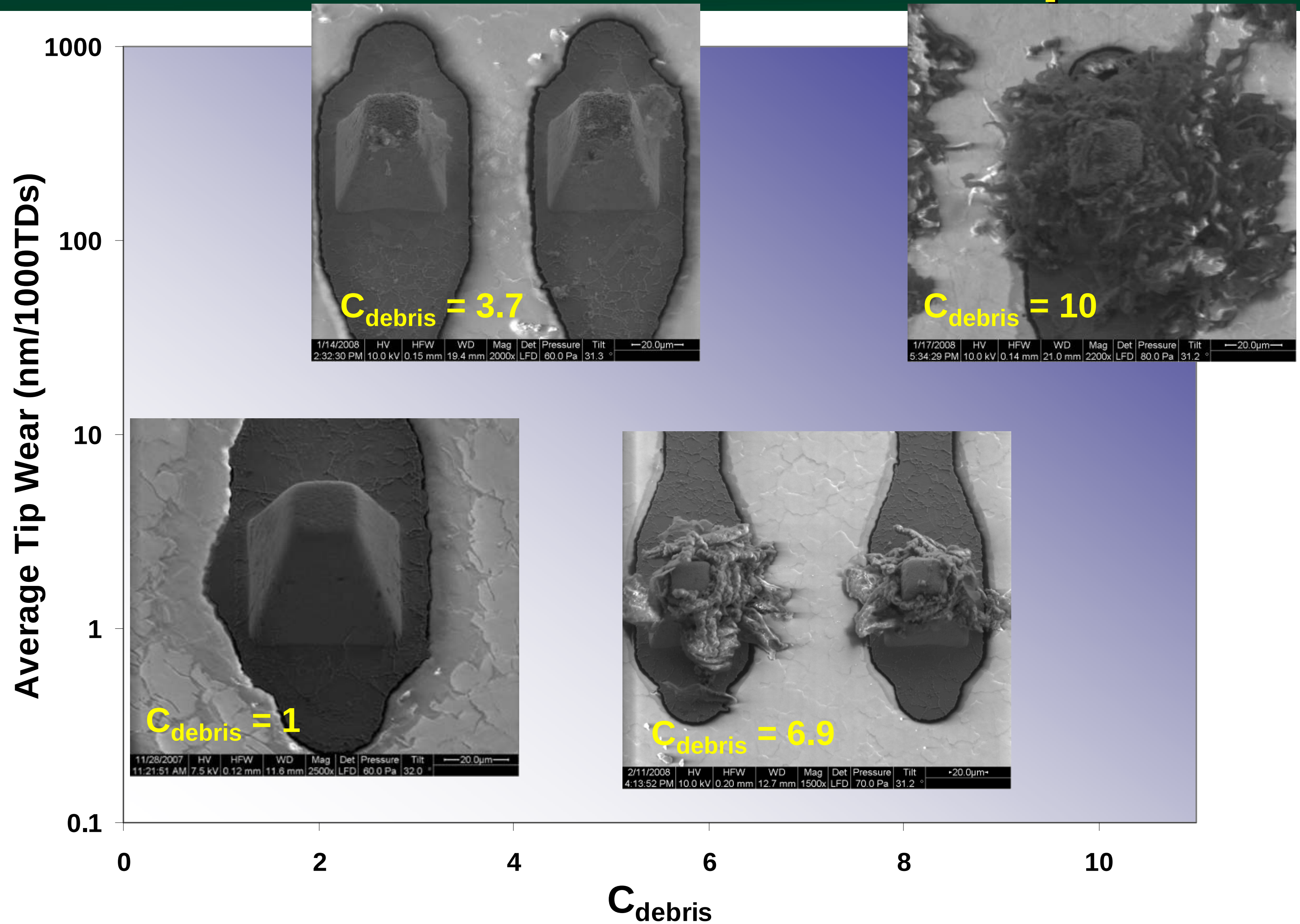
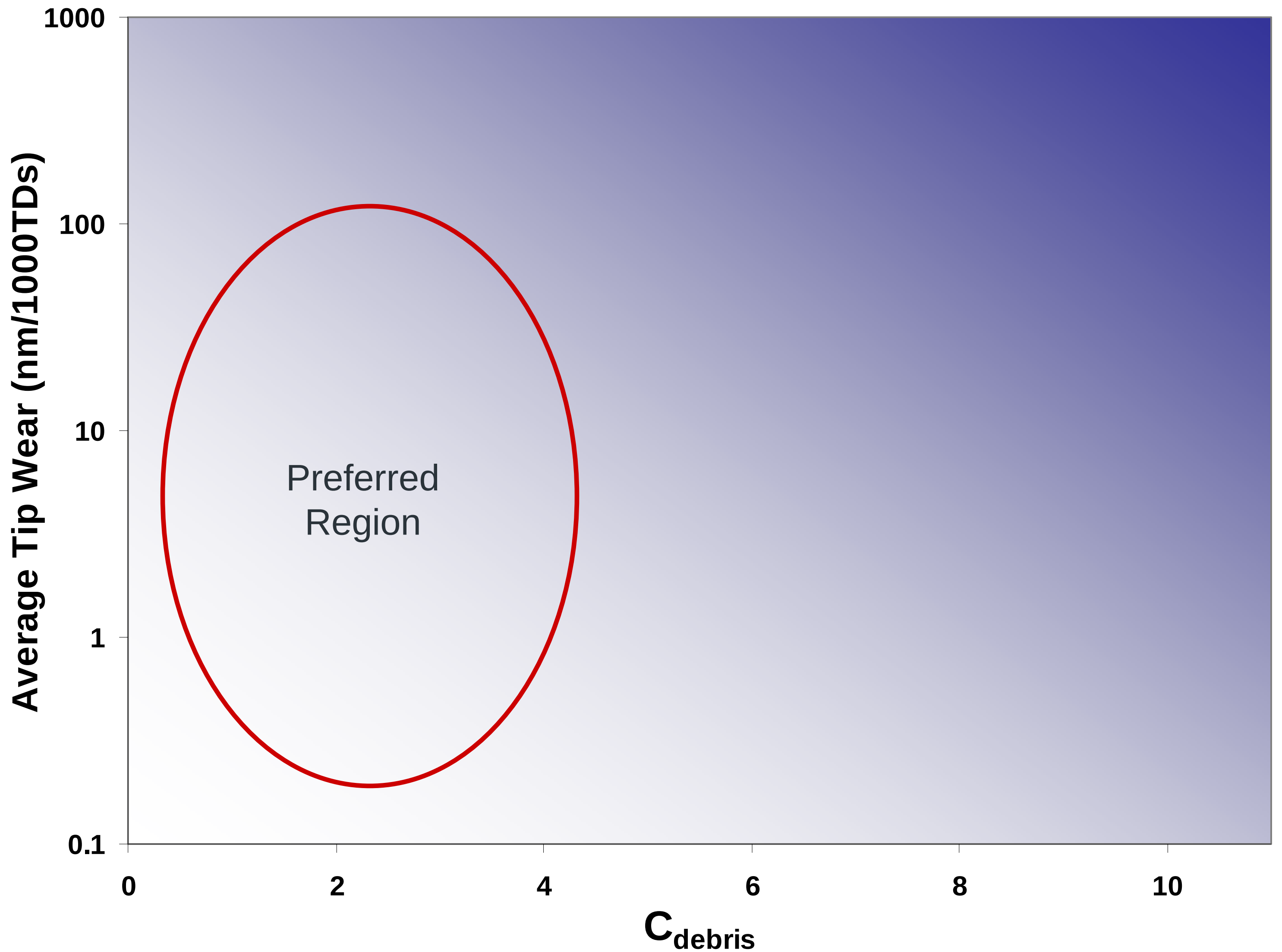


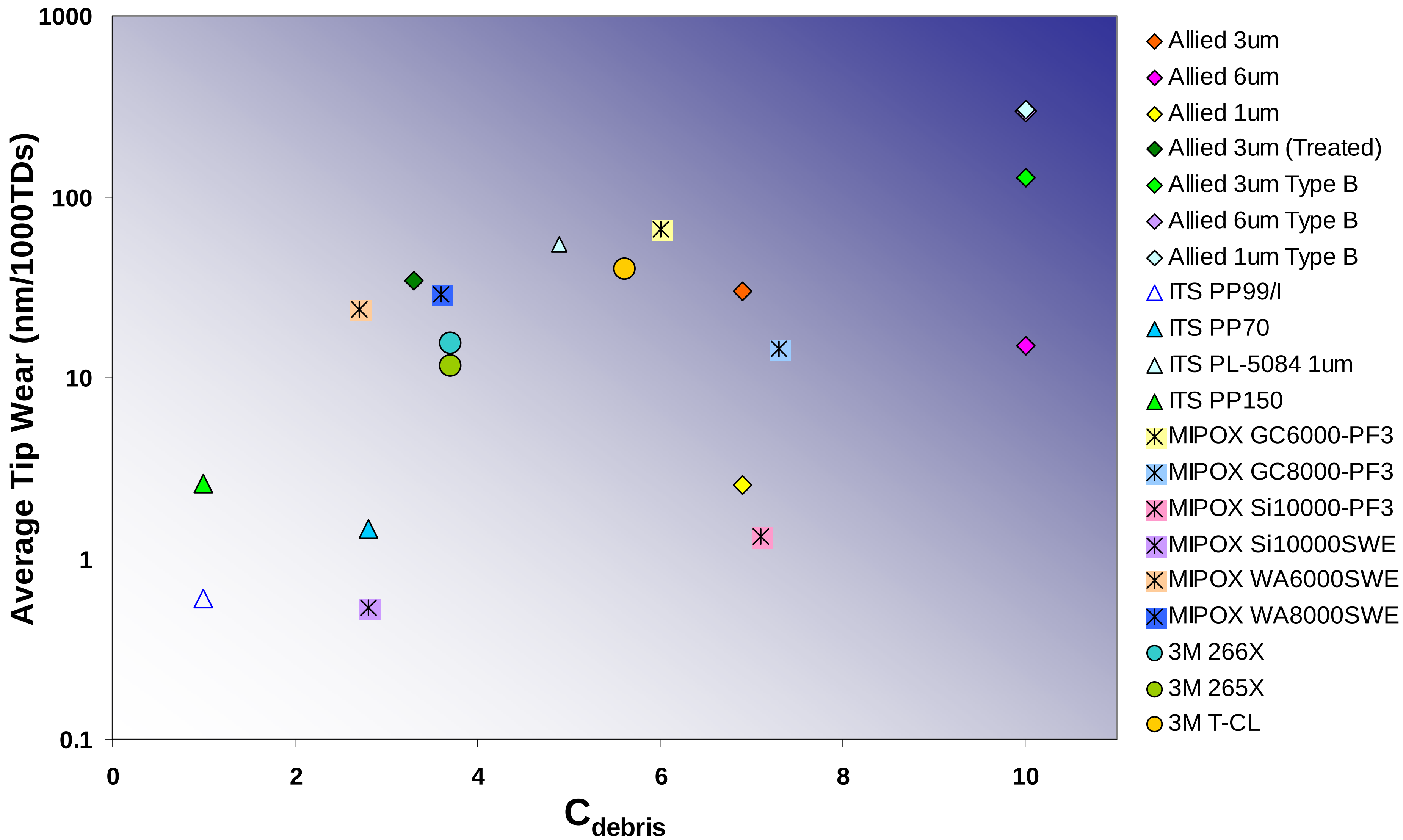
Accelerated Wear Results Graph



Accelerated Wear Results Graph



Accelerated Wear Results Graph

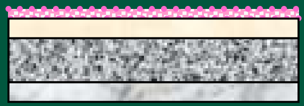


Wear Results Summary

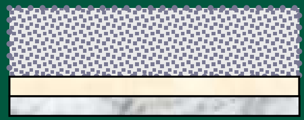
Generally Speaking:

- Apparent relationship between tip wear and particle generation
- Data from similar media type grouped together

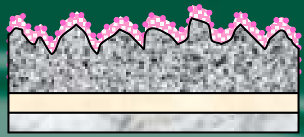
Lapping Films



Soft-Backed Lapping Films



Filled Elastomers

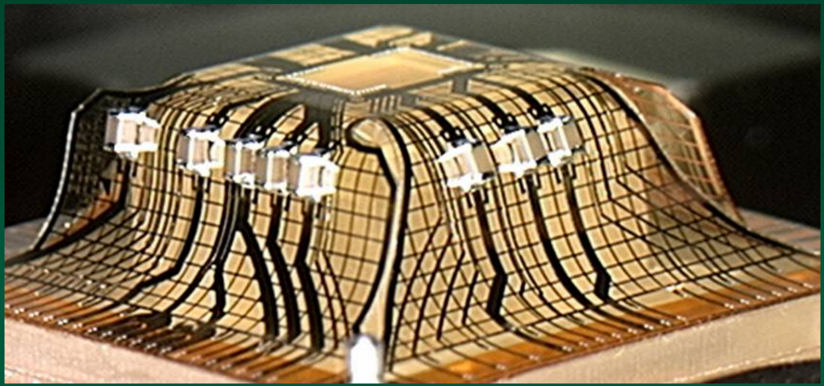


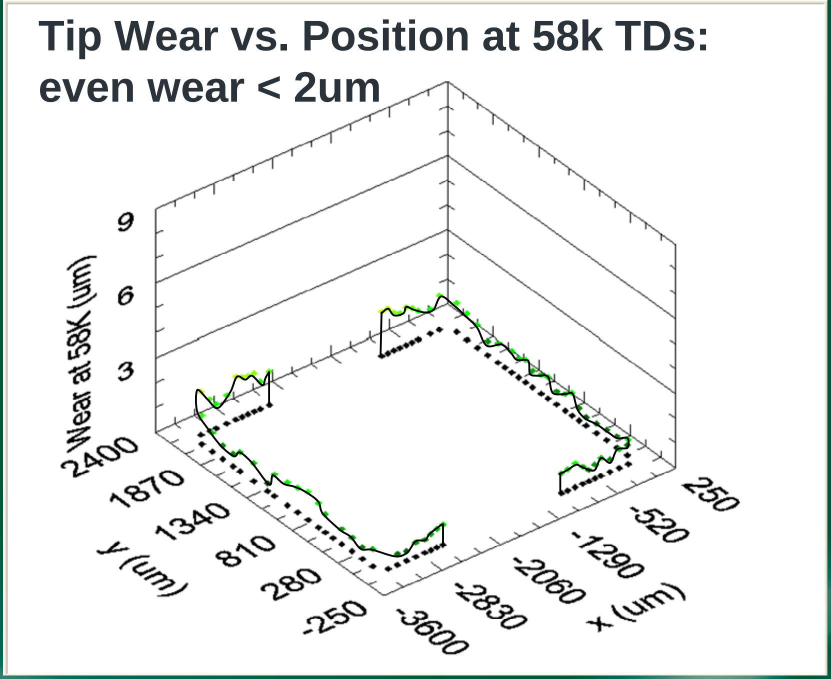
Abrasive Coated Foams

So, how did each media type perform?

Lapping Films

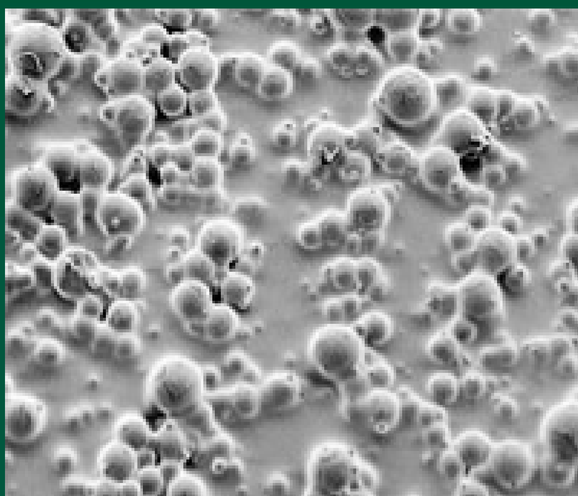
- Relatively high stiffness (1-3 g/um)
    - Low tip penetration into media
    - Particles not captured
- Even tip wear over probe tips
- Abrasion rate is:
    - Related to grit size, grit density, and grit exposure
    - Apparently not related to abrasive material
    - Insensitive to cleaning overdrive
- Wide range of particle generation
- Generally suitable for all applications





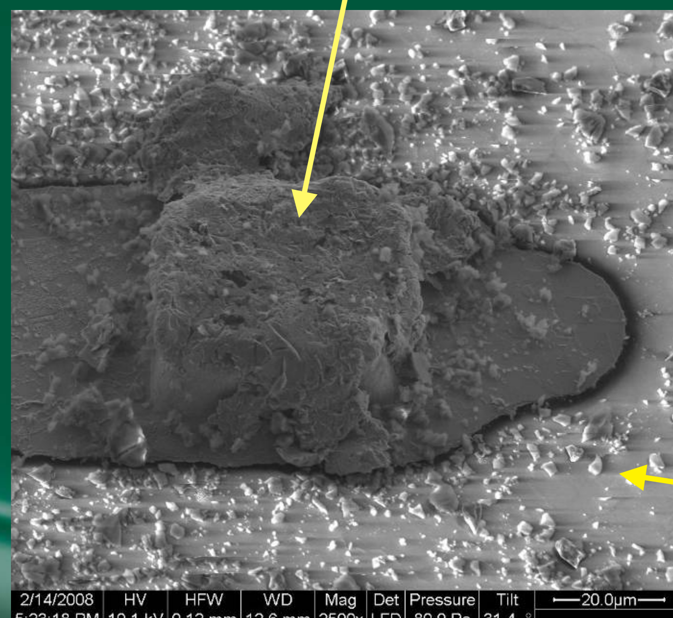
Exception: Lapping Films with Ceramic Sphere Encased Abrasive

- Not suitable for Pyramid Probe card cleaning!



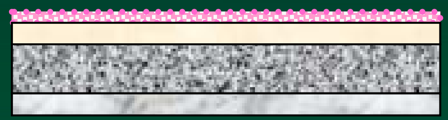
Courtesy of Allied High Tech Products, Inc.

Spherical indentations

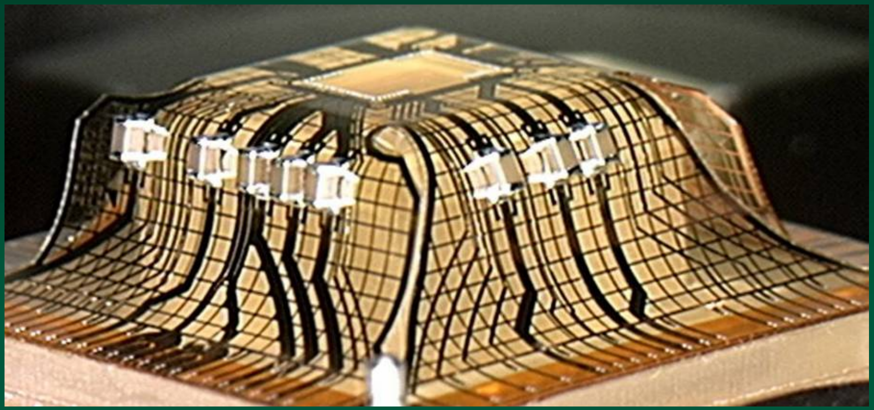


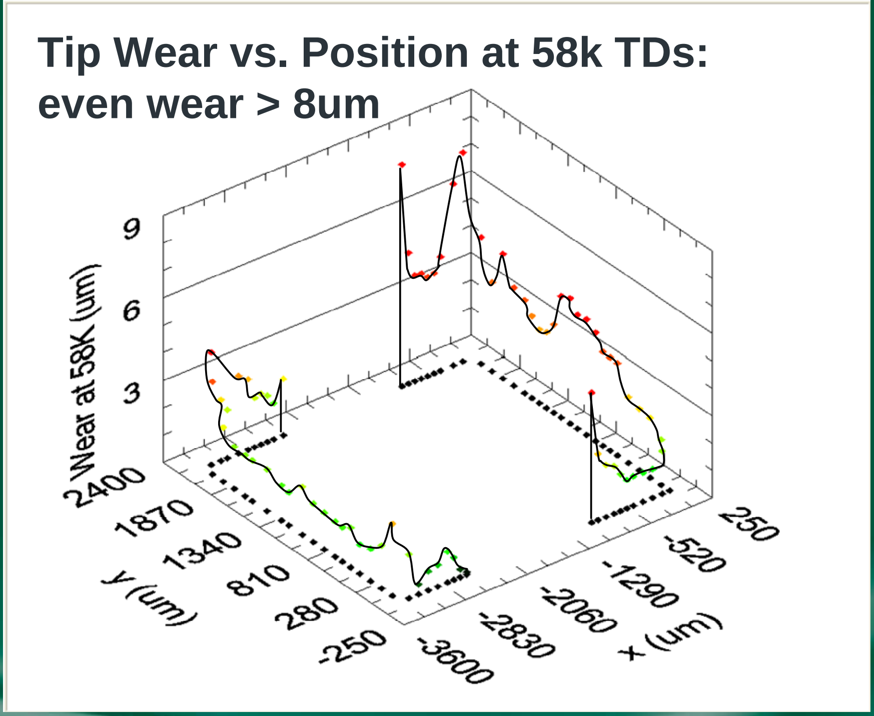
Ceramic and diamond particles

Soft-Backed Lapping Films



- Low to Medium stiffness (0.03- 0.8 g/um)
  - Moderate tip penetration into media
- Uneven tip wear
  - Hard Abrasives wear tips unevenly
  - Soft (SiO_2) abrasive OK, but probing generates lots of debris
- Not Recommended for use with Pyramid Probe cards





Soft-Backed Lapping Films: Corner-Edge Wear Mechanism (Membrane Probes)

- Two relatively stiff films, supported by soft layers
- Force is concentrated on end and corners of pattern

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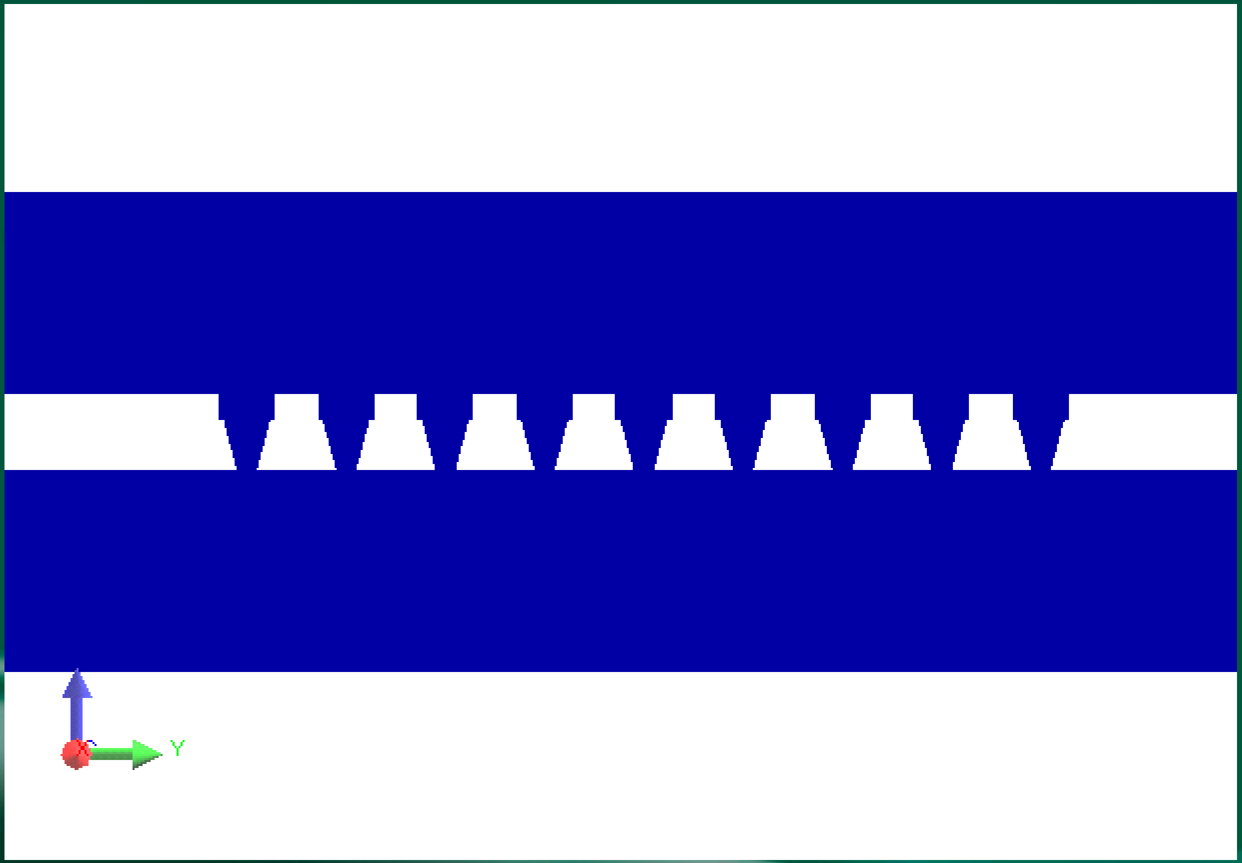
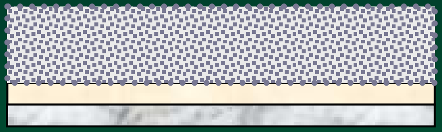
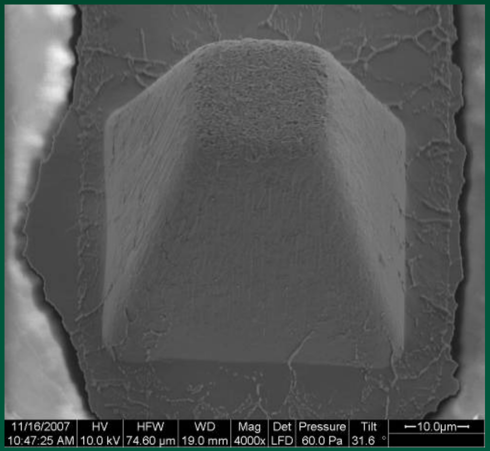


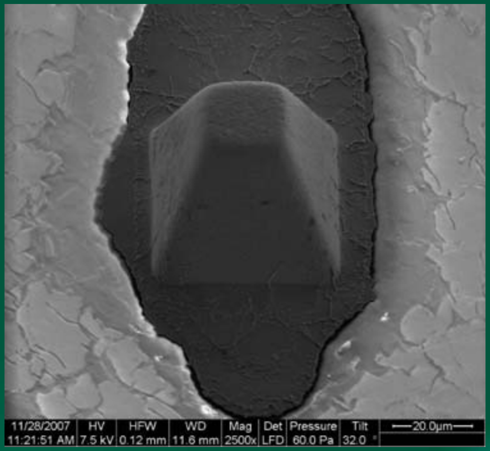
Abrasive Filled Elastomers



- Low Stiffness
  (0.01 to 0.05 g/um)
  - High tip penetration into media
  - Most of the overdrive applied deforms the media
  - Effective overdrive limited by height of tip
  - Membrane always contacts media
- Very low tip wear
- Slight tip radiusing
  - More apparent with higher abrasive loading
- Safe for all uses
- Best for long probe tip life

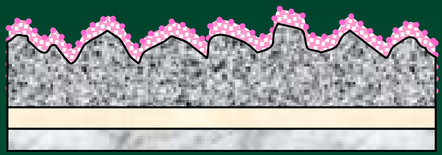


New Tip

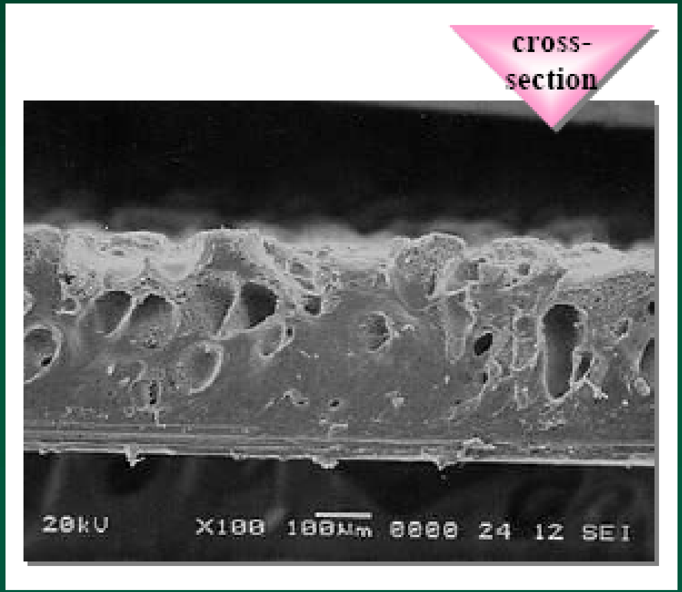


After 58k TDs

Abrasive Coated Foams

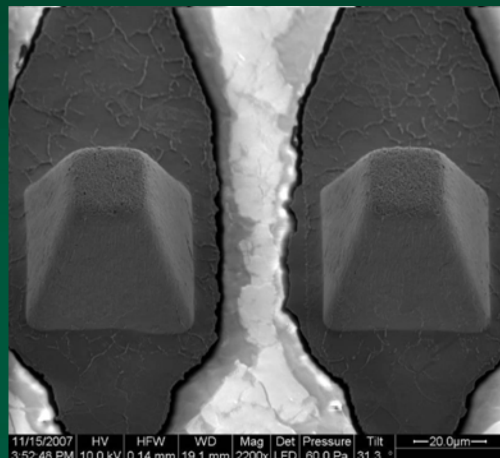


- Medium Stiffness
  (0.18 to 0.3 g/um)
  - Spring rate less consistent point-to-point than other media types
  - Moderate tip penetration into media
  - Edges of membrane contact media
- Even tip wear
- Low particle generation
- Radiuses tips

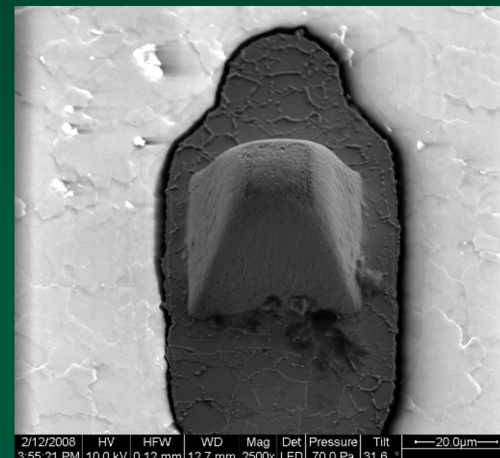


Courtesy of MIPOX International

Coated Foams Radiuses Tips



New Tips



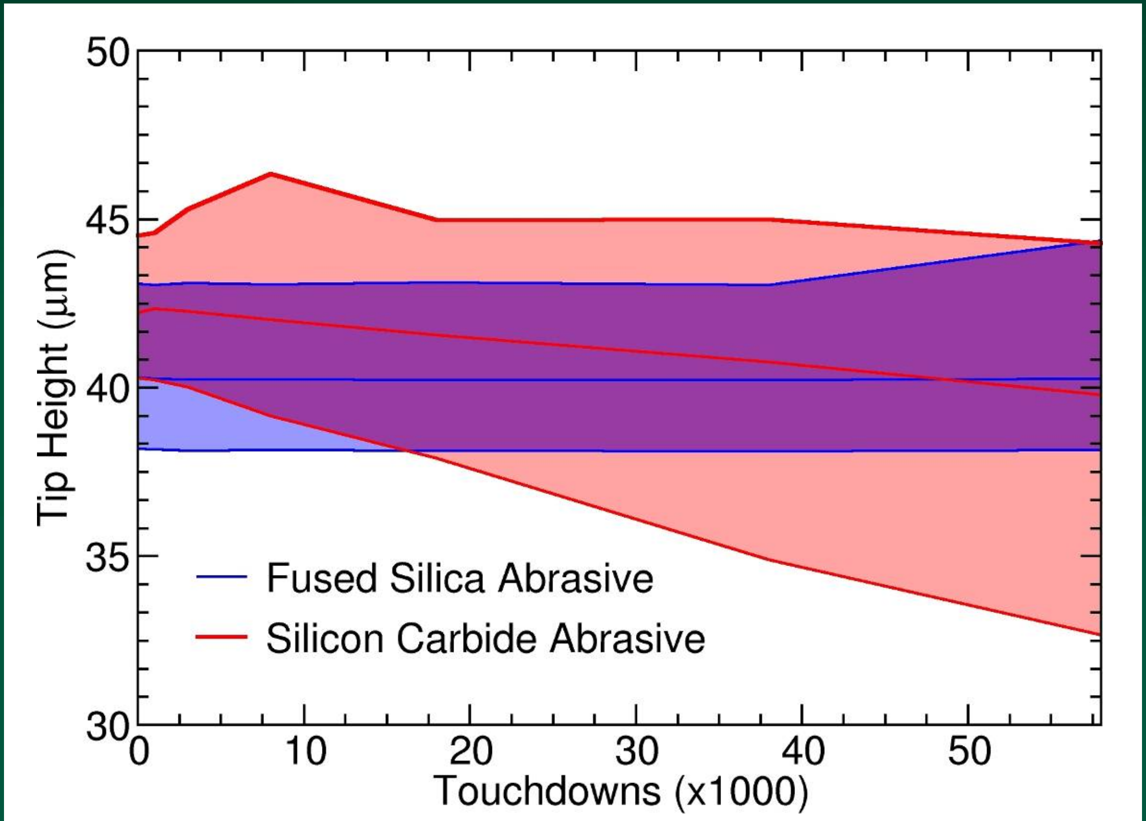
58kTDs on WA8000-SWE

- Consistent with product documentation, previous results (Broz et. al., SWTW-2007)
- May not be suitable for POAA and low-k dielectric probing
  - Decreased contact area creates increased pressure
  - Qualification at end-of-life required
- Special application opportunity for parametric (scribeline) probing

Media Type Summary

- Media type has profound difference on particle generation and wear rate, which are predominantly affected by:
  - Media stiffness
  - Abrasive grit size
  - Abrasive spacing
  - Abrasive Hardness?

Does Abrasive Hardness matter?



- Yes, but only when it is less than the tip hardness.
- Fused silica abrasive doesn't wear out Pyramid Probe tips
- Possible avenue to create an "ideal" medium

Phase 1 Results

- Media can be grouped into four classes
  - Each class has unique properties, allowing for recipe customization
  - Groupings consistent with those in *Probe Card Cleaning, "A Short Tutorial"*, Broz, et al. SWTW-2007
- Wide variety of media properties

http://www.homemadesimple.com

Phase 1 Conclusions

- Phase 1 shows which media are safe for Pyramid Probes
  - 11 media newly recommended
  - One class of media to avoid (soft-backed lapping films)

- Phase 1 survey provides a toolset for optimizing media to contaminant
  1. Maintain yield while reducing tip wear by 30X
  2. Improve yield by increasing effectiveness of cleaning
  3. Extend interval between cleaning touchdowns

- We assume that media actually clean probe tips, which is not supported by data– yet.

Next Steps: Phase 2 Survey

- Phase 2: Verify cleaning effectiveness with R_c measurements
  - Focus on solder ball wafers
  - Blanket aluminum wafers
  - Use safe media found in Phase 1
- Apply results to minimize Pyramid Probe Cost of Ownership

- Work with suppliers to develop “ideal” media

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- Eric Abel, Ph.D., Cascade Microtech