Advanced CMP Cleaning Solutions

Surfactants, Metal Inhibitors, Oxygen Scavengers & Particle Removers

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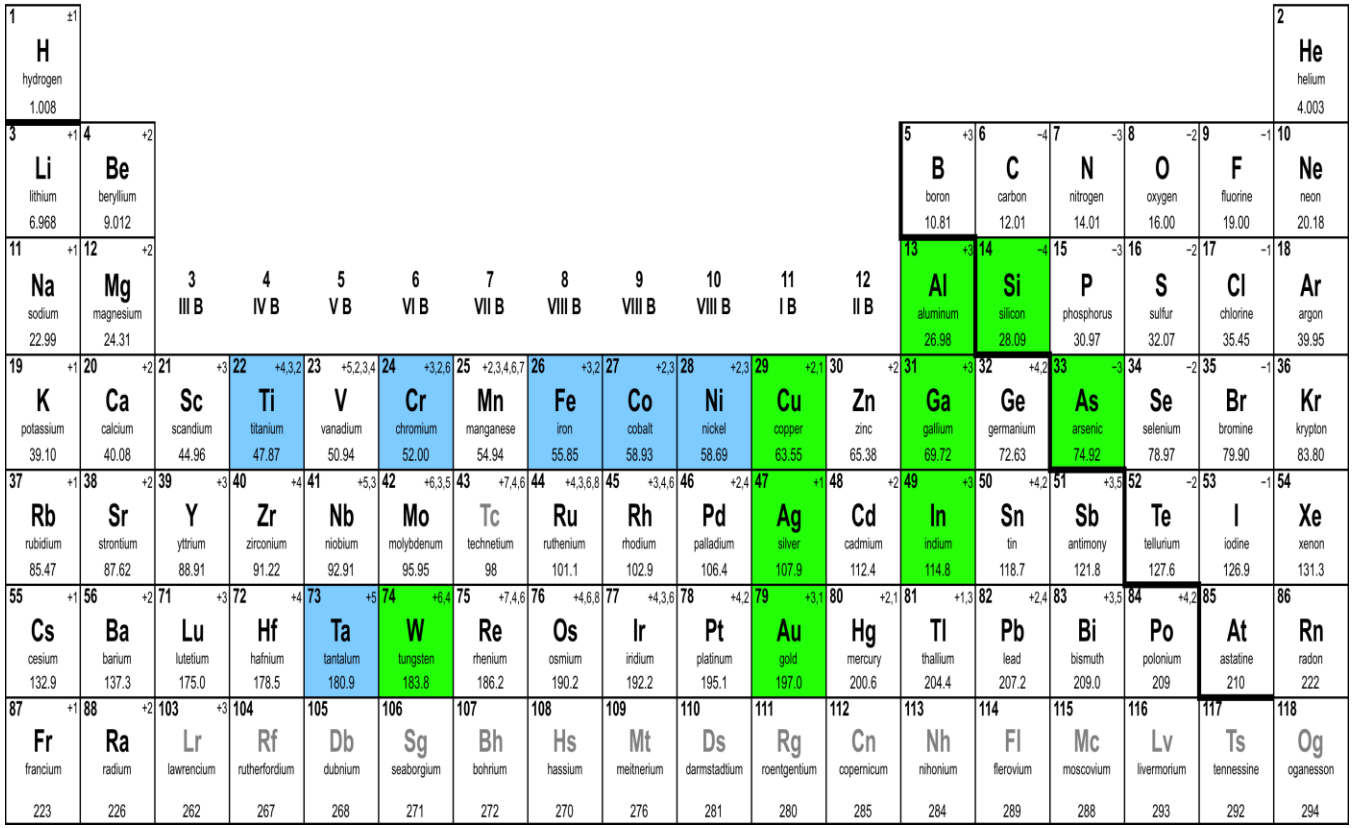
- Challenges of CMP Cleaning
- Background and Principles of CMP Cleaning
- New Concepts in CMP Cleaning
- Fab Experimental Results
- Summary

Challenges of CMP Cleaning Solution

- **Multiple materials in Dynamical CMP Systems**
  - Trace metals and ions: **Cu**, W, Ni, Fe, Ru, Ti, Cr, etc
  - Dielectric material: SiO_2, Al_2O_3, etc
  - Slurry residuals: PSD, MOx
  - Organic polymer materials
- **Cleaning Mechanism for Different Materials**
  - Cleaning chemistry vs. CMP chemistry; pH, corrosion & inhibitors
  - Metal surface cleaning
  - Dielectric surface cleaning
  - Wafer surface topography, structures, macro & micro-scratching
- **Cleaning Tool and Cleaning Functions**
  - Different tools, masonic, rinsibility & dry methods
- **Wafer Quality, CMP Process Performance**
  - Wafer aging, CMP process performance & recontamination
  - Partial dried wafers & wafer surface slurry residual pre-treated

Challenges of CMP Cleaning Solution



MP Related Materia	
1	AlOx
2	SiOx
3	Cu
4	W
5	Al
6	MOx
7	Polymers
8	SiN
9	TiN
10	Redep

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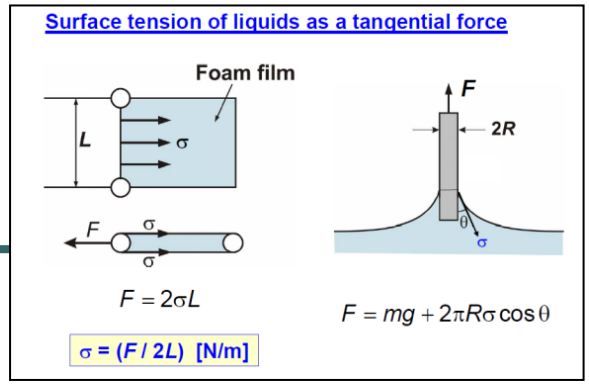
Key Issues of Cleaning Chemistry

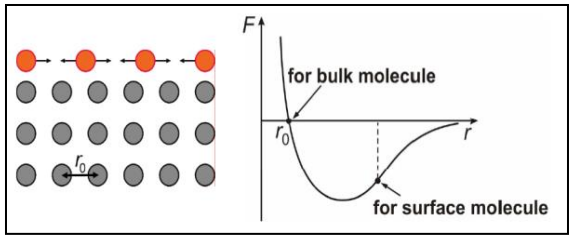
- **Unbalance of Hydrophilic/Hydrophobic of Surfactants**
  - Poor vehicle of slurry
    - Poor uniformity of slurry across pad
  - Poor surface modification of particles, such as SiO_2, CeO_2
    - Agglomeration of particles
    - Wide distribution of particles - macro and micro-scratching
  - Residual slurry particles, Al_2O_3, colloidal SiO_2, and CeO_2
  - Cleaning residual of BTA in Slurry

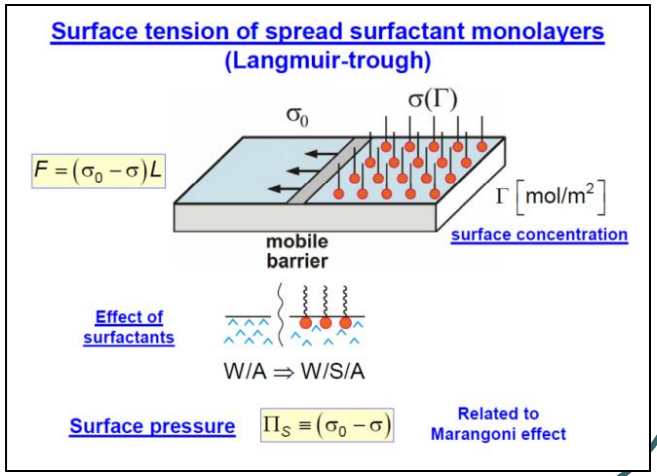
- **Incompatible of Metal Inhibitors/Oxygen Scavengers**
  - Non-uniformity of particle dispersion in solution
    - Corrosion of metal, Cu, and W
    - Recontamination
  - Aggressive chemicals, high or low pH
    - Corrosion
    - Macro or micro–scratching
    - Poor rinsibility

Cleaning Fundamentals

- **Cleaning Mechanism**
  - Hydrophilic/Hydrophobic balance
  - Surface tension
- **Metal Cleaning with Inhabitors (BTA)**
  - Better removing particle
  - Corrosion on metal
  - pH range
- **Classic Non-ionic Surfactants (NIS)**
  - Removing particles
  - Removing Organic Contaminations
- **Ionic Surfactants (IS)**
  - Aliphatic phosphorous surfactants
  - Metal surface protection
- **Chelating/Complex Chemicals**
  - Cleaning/removing metal ions and oxides







New Cleaning Concepts
Surfactanized Metal Inhibitors with Cleaning Functions

- **Surfactanized Metal Inhibitors**
  - Hydrophilic metal inhibitor on one side
  - Short aliphatic hydrophobic tail
  - Maximized protection on metals: **Cu,** W, Ru, Ni, Fe

- **Surfactanized Oxygen Scavengers**
  - Long ethoxylated hydrophilic tail
  - Hydrophobic oxygen scavenger
  - Max scavenged oxygen throughout CMP process

- **Special Surfactants**
  - Ethoxylated hydrophilic tail
  - Short hydrophobic chain with chelating agent
    - Much better vehicle
    - No **amines (TMAH**) compounds

Briteclean System – How does it work?

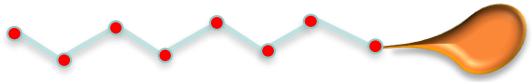
Hydrophilic
Metal Inhibitor Head

Aliphatic
Hydrophobic Tail

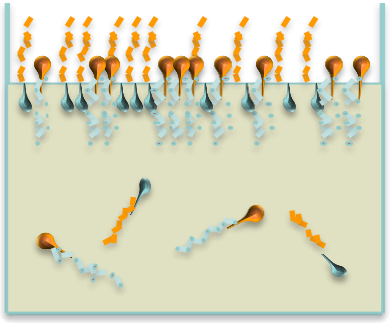
+

Ethoxylated
Hydrophilic Tail

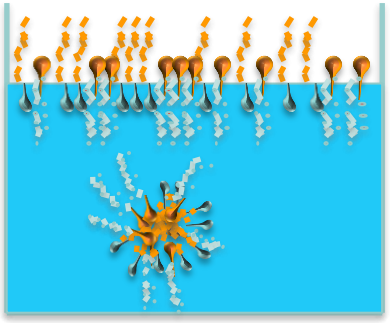
Anti-oxidant
Hydrophobic Head



Briteclean-0plus
Britclean-Ultra



Briteclean-1

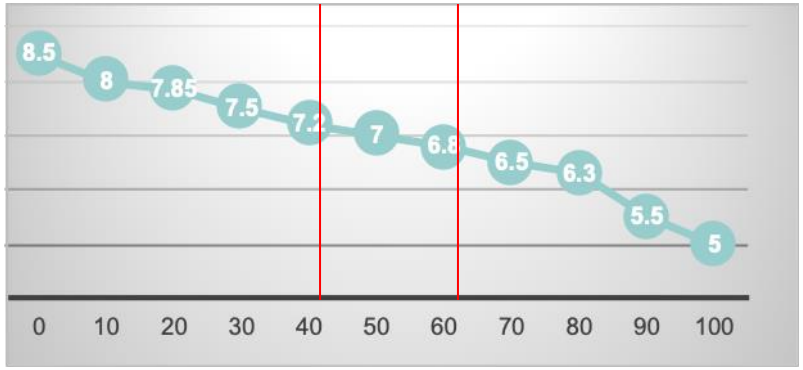


Briteclean-0plus/Ultra : Briteclean-1
= 1:1 Diluted 50 to 1

Briteclean-0 : Briteclean-1 = 1:1
No dilution

Phase Separation

Briteclean System
pH Control and Application Conditions



	Briteclean - 0/Plus	Briteclean - 1	Briteclean-ACP
Pre/Post Cleaning Process	YES	YES	YES
Slurry Additives	YES	YES	YES
Storage/Buffer	NO	NO	YES
Application	Need to mixing with BC-1 or BC-ACP	Need to mixing with BC-0/plus	Solely
Usage	1% - 5%	1% - 5%	1% - 4%

Recommendation: BC-0plus/BC-1 = 1:1; Diluted to 1%-2% with DI water

- **Process Conditions:**
  - CMP Tool (8inch): Applied Mirra; Ebara; 6DSSP(Strausbaugh)
  - Slurry: Cabot MH8xx system; ASL system
  - Pad applied: IC1000; Sub IV
  - Cleaning Tool: DNS, SSEC
  - Cleaning solution: Briteclean-1; Briteclean-0plus
    - Mixed: Ratio 1:1 in 1.0% - ~2% Aqueous media
  - Wafer: **Cu, W, TiN, TaN,** Ni, Fe, Low key, SiOx, Al_2O_3, Ru, etc

Briteclean-Ultra: pH~9.5
Briteclean-3D: pH~5.0

Metal and Cl Elements Content in Briteclean products

Metal Elements (ppb)	Briteclean-0+	Briteclean-1	Briteclean-ACP
Fe	<20	22	53
Cu	28	<5	25
Ni	18	<5	<5
Zn	<5	<5	<5
Pb	<5	<5	<5
Cr	<4	<4	5
Mn	<5	<5	<5
Co	<5	<5	<5
AS	<25	<25	<25
V	<25	<25	<25
Al	<20	32	25
Ti	<20	<20	<20
Mg	<20	<20	<20
Cl	<20	<20	<20

1: Cu, Ni, Zn, Ti, Pb, Mn, Co, V, As were analyzed by EPA Method 200.8 on an ICP-MS (Perkin Elmer DRC-e)

2: Fe, Al, Cr were analyzed by EPA Method 200.7 on an ICP-OES (Thermo iCAP 6300 DV)

3: Cl was analyzed by EPA Method 300.0 on an IC (Metrohm 850)

Note 1: ICP-MS Analysis
2: "<" means below detection limit

Corrosion Test – Cu Wafer

Testing Instrument

- Solution Fixture
- Std Corrosion testing Cell
- Solartro Electrochemical
- Corrosion testing interface

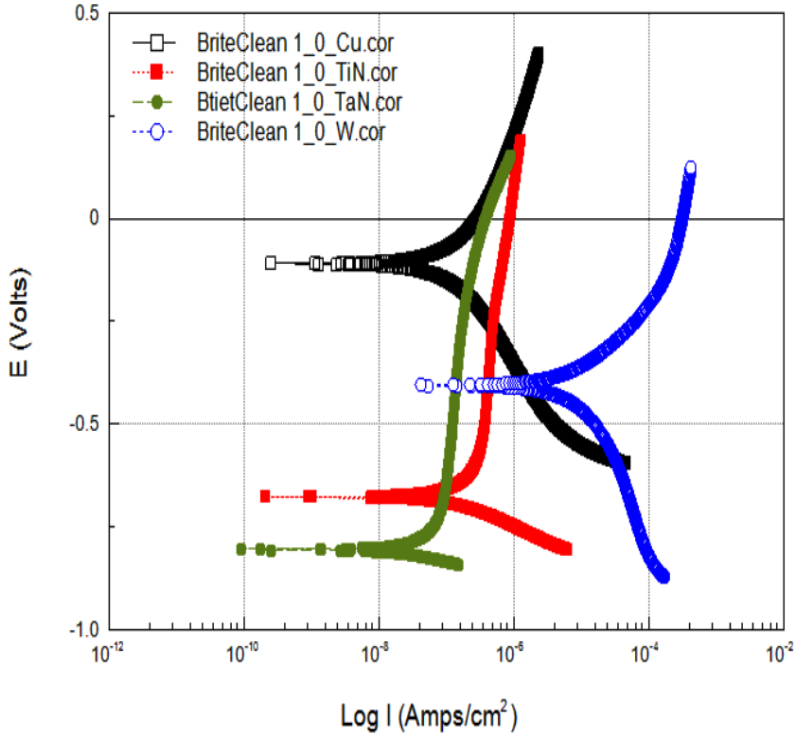
Corrosion Test Outputs

- Tafel/Linear Polarization – Corrosion Rate Measurements
- Galvanic Corrosion Current Measurements
- Electrochemical Impedance Spectroscopy
- Corrosion Rate Measurements under Abration

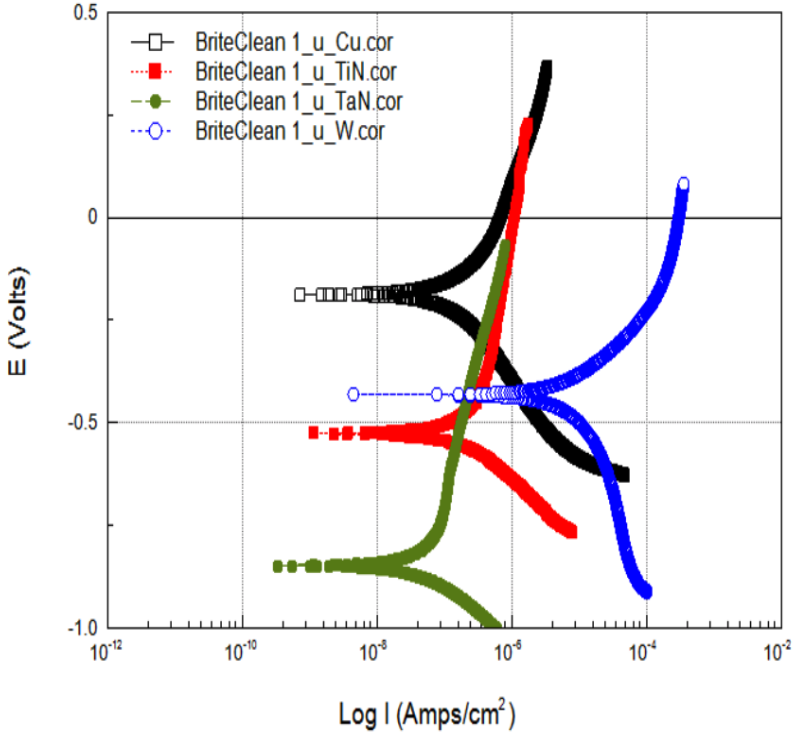
Corrosion Testing Results – Cu Wafer

Solution	OCV (vs SCE)	RP (Wcm2) (from linear)	io (A/cm2)	ERR (Angstrom/min)
DI H2O	-0.0614	10.8	4.18E-06	0.9236
Best Competitor	-0.242	2135	1.22E-05	2.6845
Another Competitive	-0.294	685	3.76E-05	8.302
Briteclean-0+ /Briteclean-1 = 1:1 2% aqueous	**0.1017**	**3645**	**7.05E-09**	**0.0016**
Briteclean-0+ /Briteclean-ACP =1:1 2% aqueous	**0.1585**	**2180**	**1.20E-08**	**0.0026**

Corrosion Testing Results BC-0plus, BC-1 and BC-Ultra on Cu, TiN, TaN and W Wafer



	BriteClean 1_0 (1:1:48)			
Substrate	Cu	TaN	TiN	W
Ecorr (V)	-0.10764	-0.80145	-0.67662	-0.40374
Icorr (A/cm²)	2.13E-07	-8.45E-08	1.98E-07	9.31E-06



	BriteClean 1_Ultra			
Substrate	Cu	TaN	TiN	W
Ecorr	-0.18517	-0.52489	-0.84506	-0.4298
Icorr	2.60E-07	3.29E-07	9.69E-08	9.14E-06

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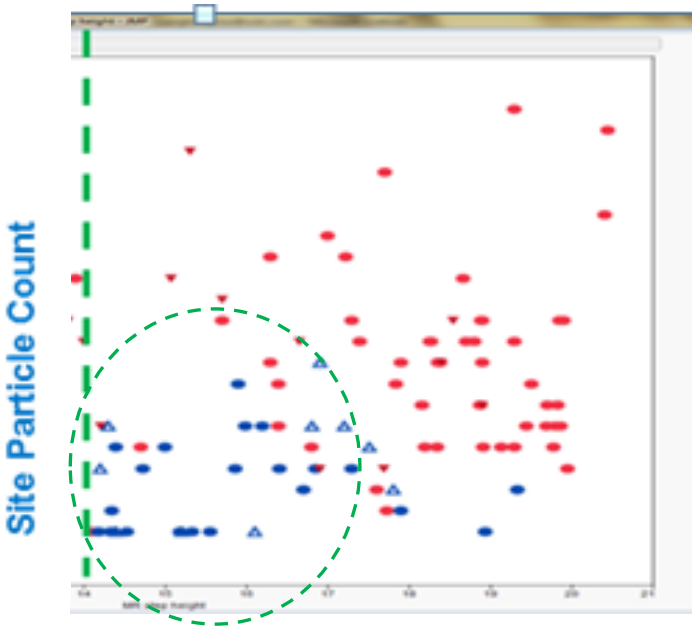
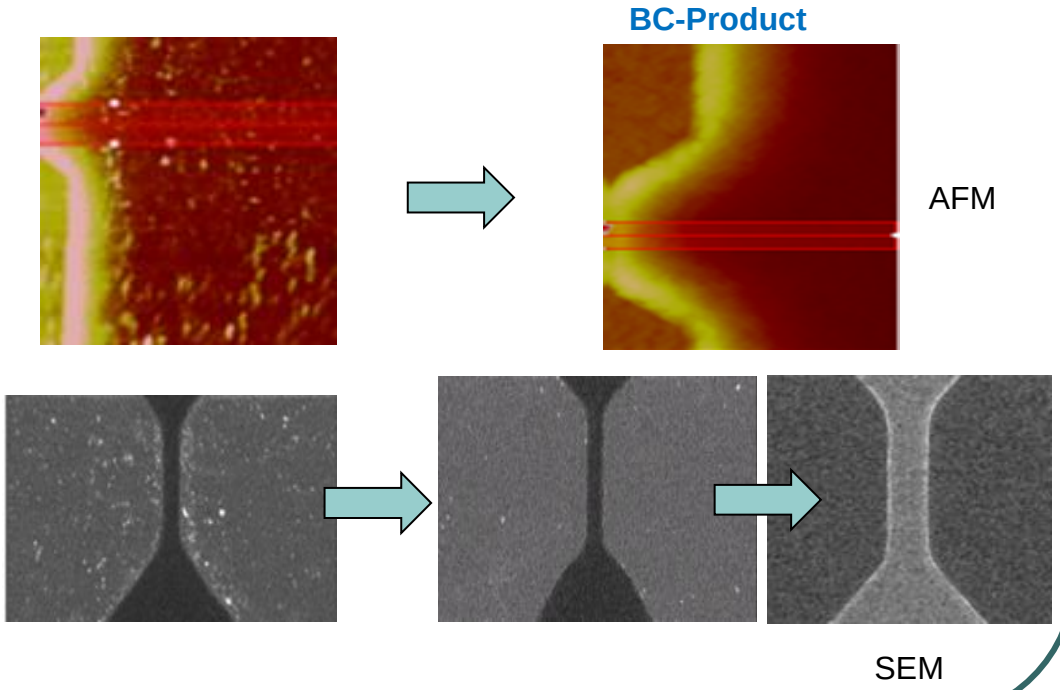
Briteclean System –Applications

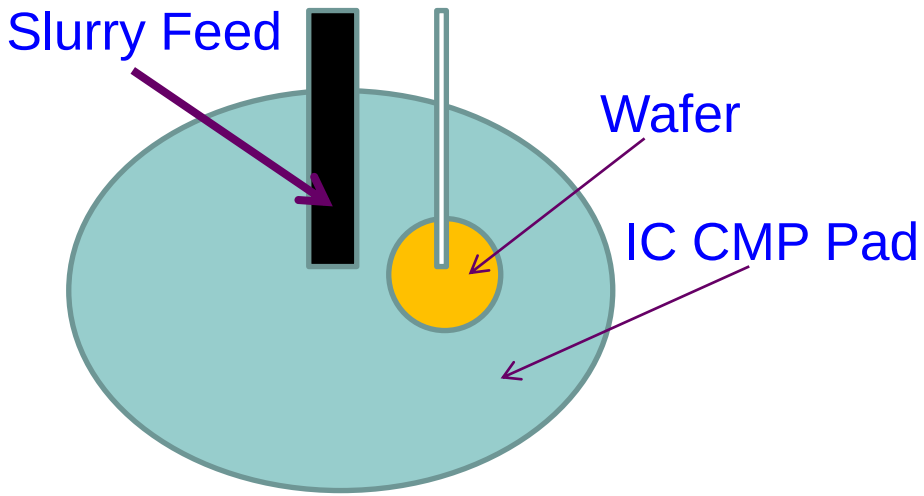
- **Briteclean products are qualified on 7 Major US fab lines**
- **Particle Reduction**
  - BC cleaning system showed better particle count reduction
  - BC cleaning system showed >40% particle reduction on device production wafers





Principle of Slurry Additive for CMP Applications

- Slurry distribution on polishing pads is a critical factor to achieve better WIW uniformity
- Adding Brizon products into CMP slurries, the slurry surface extension with IC series CMP pads was modified to a form a uniformed slurry layer across the whole wafer



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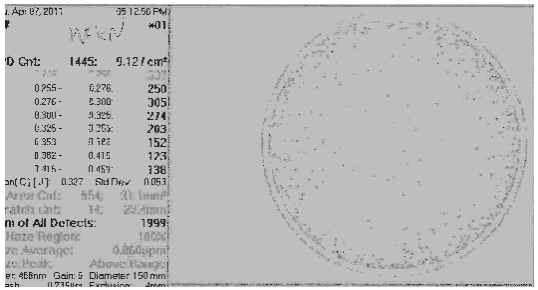
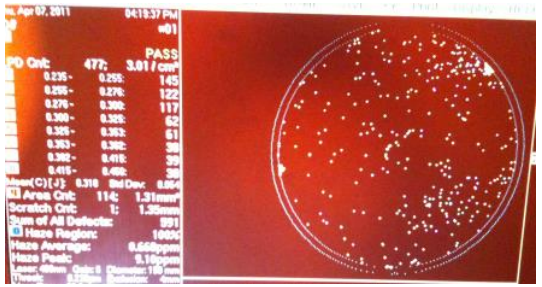
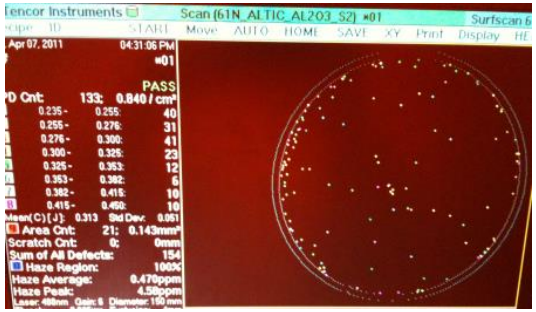
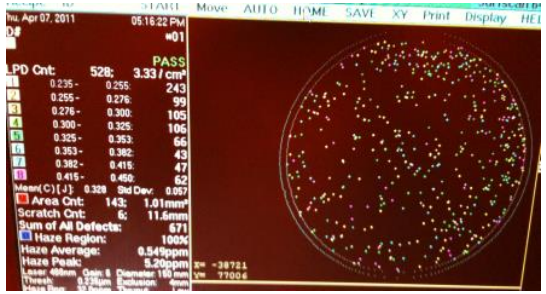
Surf-Clean Imaging
For Competitor's Clean Solution

	Pre-Treatment	Post-Treatment
Alumina		
Cu		

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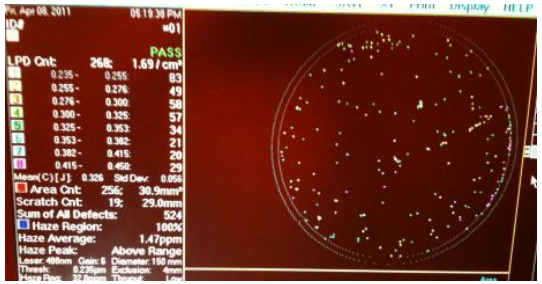
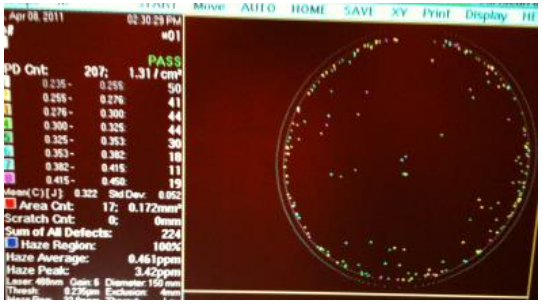
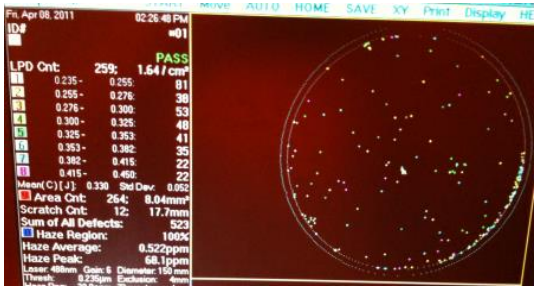
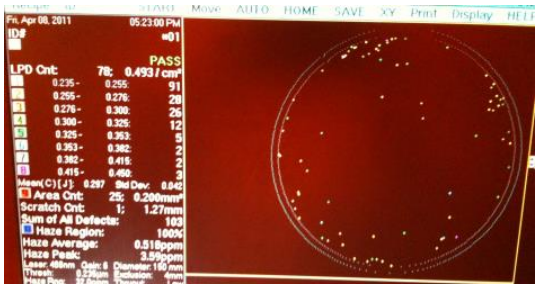
Surf-Clean Imaging
For Briteclean Clean Solution

	Pre-Treatment	Post-Treatment
Alumina		
Cu		

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Different Slurry Cleanability of Briteclean vs Competitor's

BriteClean mixed Solution		
	Alumina	Cu
Con-1	-70	-66
Con-2	-22	-340
Competitor's Cleaning Solution		
	Alumina	Cu
Con-1	190	280
Con-2	1571	370

Different Method Cleanability of BriteClean vs Competitor's

BriteClean mixed Solution		
	Alumina	Cu
Roller	10	24
Pencil	-10	-6
Competitor's Cleaning Solution		
	Alumina	Cu
Roller	318	2985
Pencil	190	280

Average Particle counts for Briteclean Products on Cu Surface

Briteclean Products	AlOx	SiOx
Briteclean-0	-20	-6
Briteclean-0+	-30	-20
Briteclean-3D	-73	-56
Briteclean-Ultra	-154	-137

Note: Mixed with BC-1, 1:1 ratio (5%:5% in DI H2O), on Pencil tool

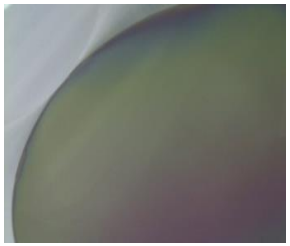
Principle of Cleaning Process for CMP Applications

- Slurry: → Dissolved/Dispersed into Advanced Nonionic Surfactants, Slurry Chemistry
- Trace Metals: → Dispersed into Advanced Nonionic Surfactants
- Metal Ions: → Complex to Chelate in the Cleaning System
- Aggressive Corrosive High/Low pH: → Buffered by the Cleaning Solution

Briteclean System –Applications

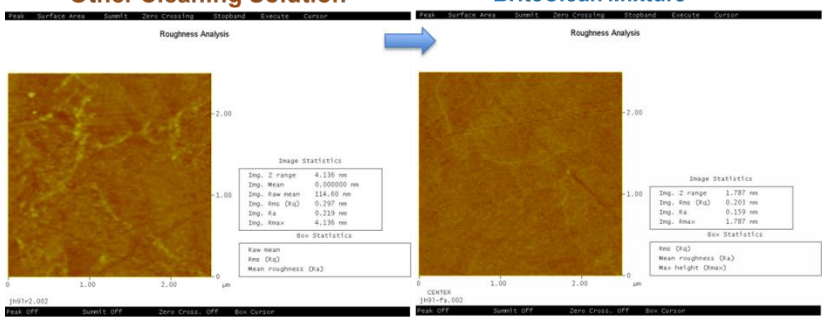
- **Surface Quality improved**
  - Prevent AlO_x wafer surface without pitting with BC products
  - Metal surface improved

Full AlO_x film pitting – long time in DI water



No film pitting – x2 time in DI water + Briteclean

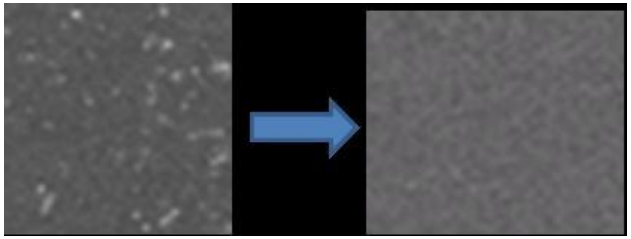
Other Cleaning Solution | **BriteClean Mixture**



Average Roughness(N=3x3): Rms=0.34nm | Average Roughness(N=3x3):Rms=0.29nm

Cu AFM Image

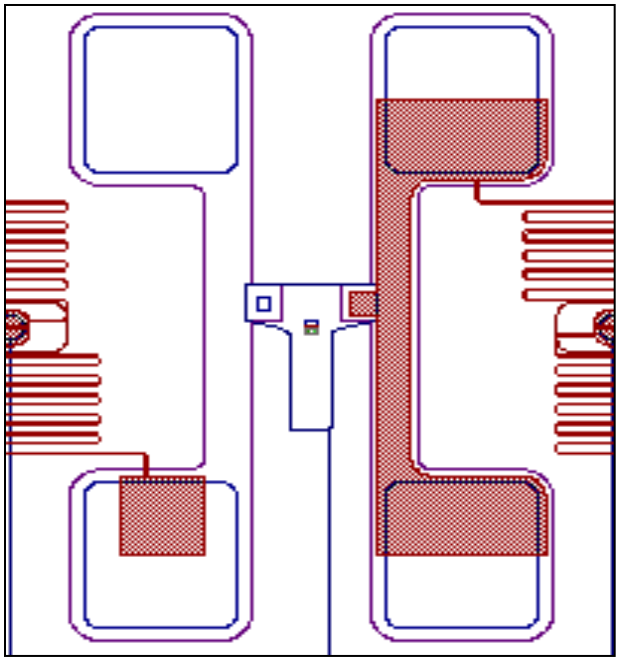
Other Cleaning Solution | **Briteclean Cleaner**

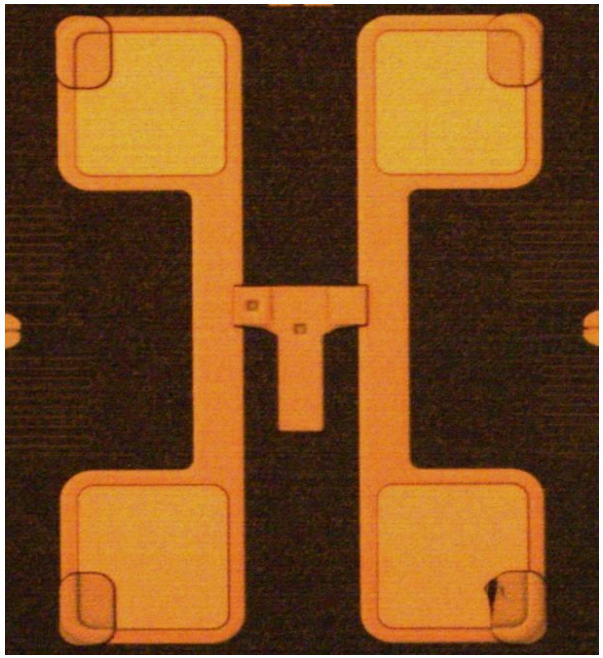


Cu SEM Image

Briteclean System –Applications

Sensor Circuit Measurement

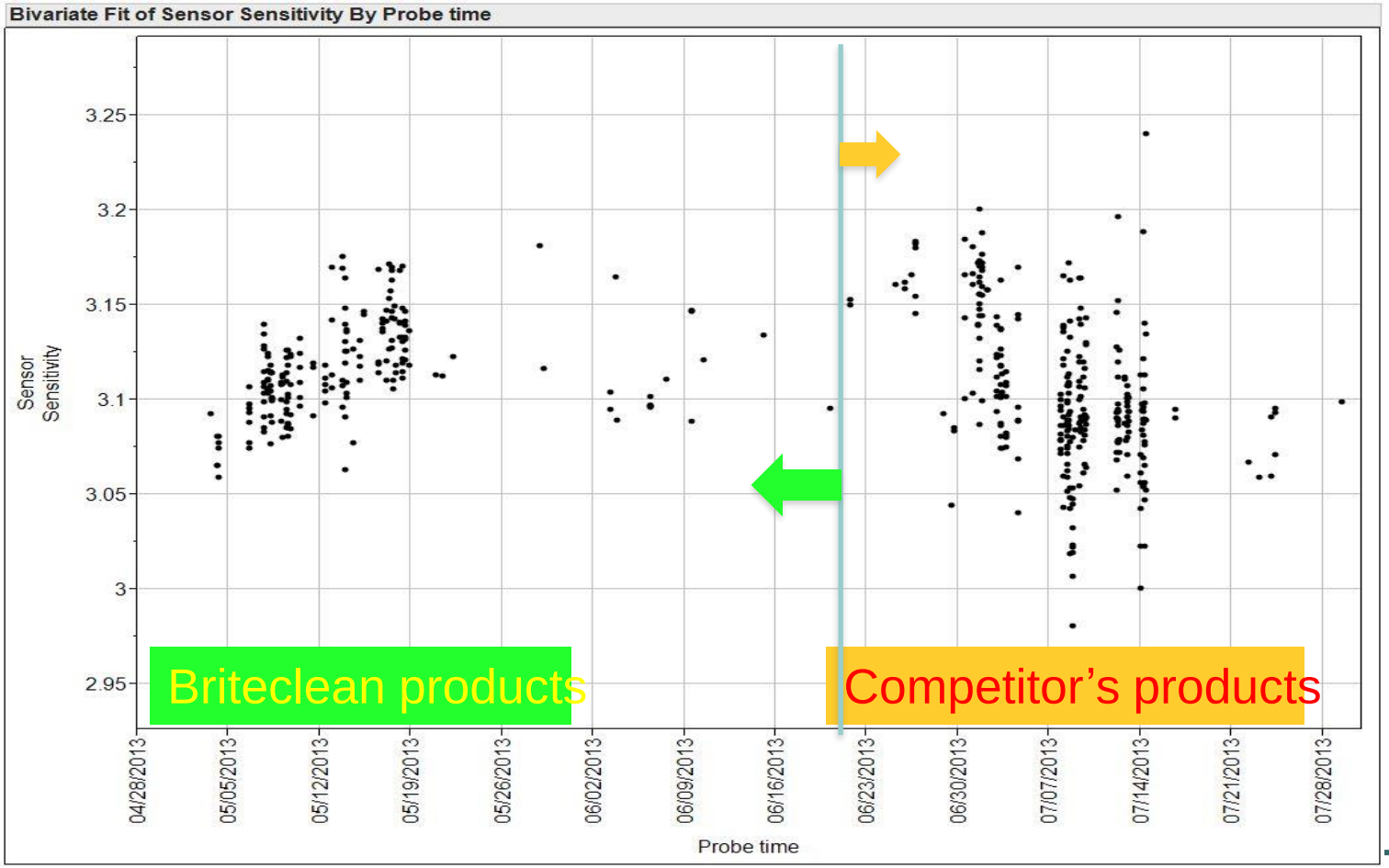




- Sensor dimension was designed per different usages.
- 4-point scheme minimizes contact resistance during probing

Briteclean System –Applications

Sensitivity Measurement Trend Chart



Summary

- Briteclean Products use a new surfactanized metal inhibitor and anti-oxidant cleaning approach
- Cleans major metal surfaces, dielectrics materials, slurry & photo residues with one solution
- Highly efficient cleaning with significant particle reduction and better surface quality
- Easier to handle and simpler process on all tools
- Briteclean products in daily use on many fab lines for over 9 years
- Other advanced cleaning products also available