Aqueous-based Thick Photoresist Removal for Bumping Applications

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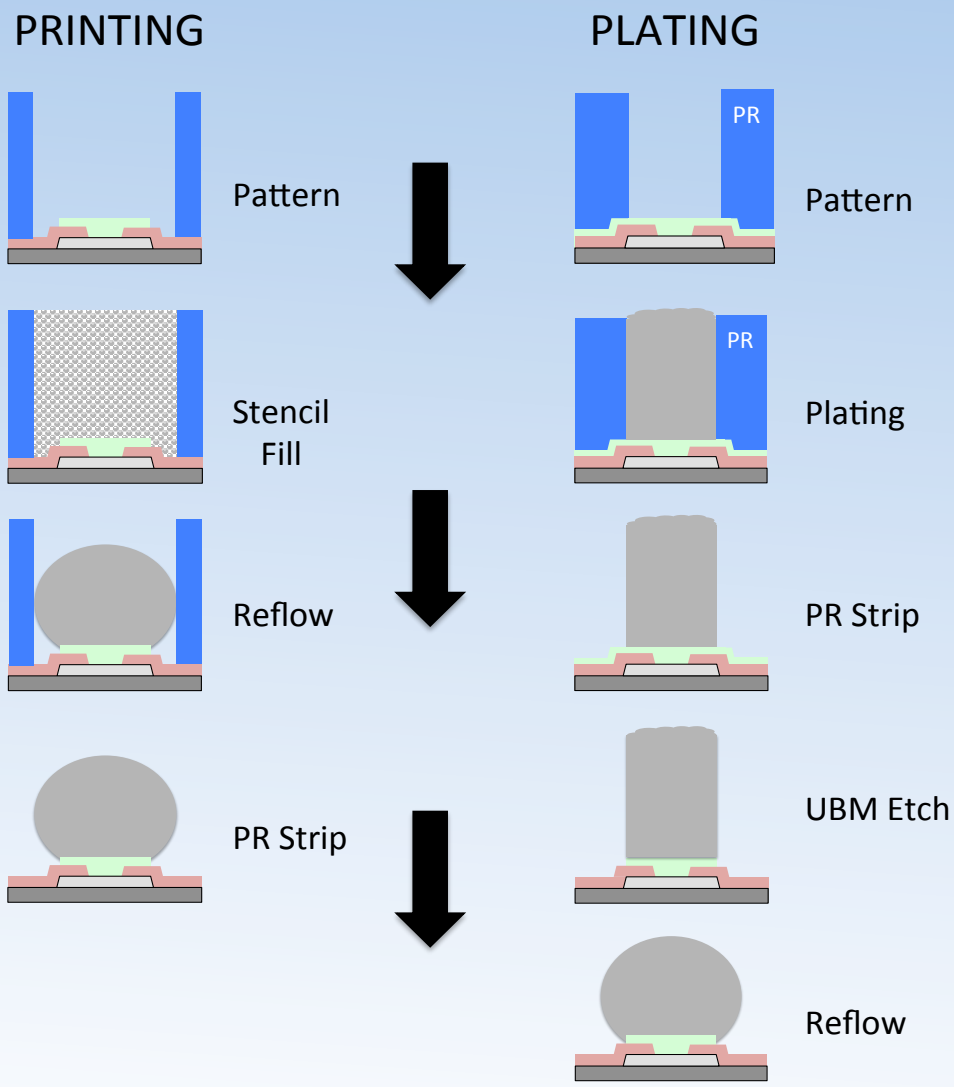
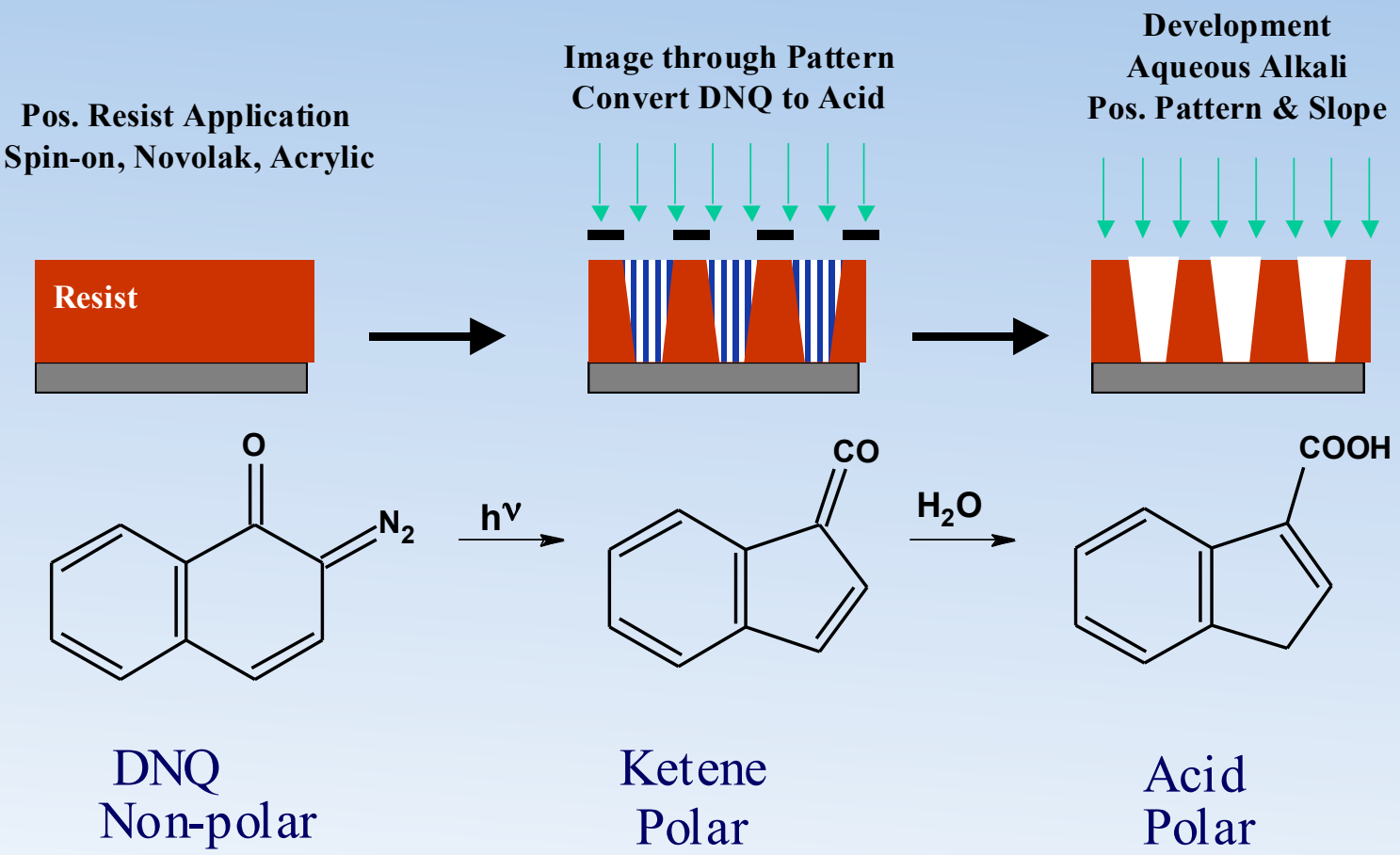
Photoresist in Bumping Applications



Typical PR Process - Positive



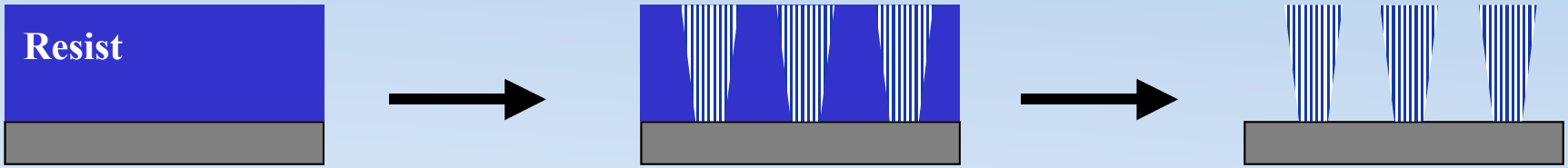
Dissolves Positive PR

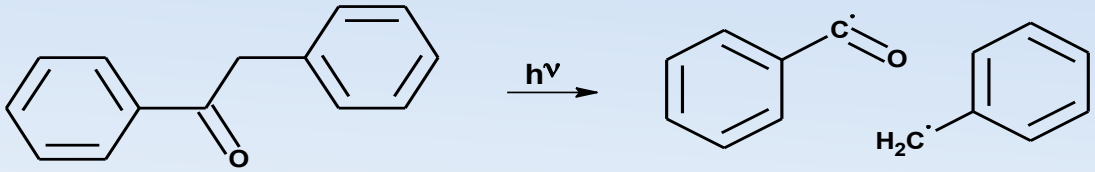
Typical PR Process - Negative

Neg Resist Application
Spin-on, Dry Film
Novolak, Acrylic,
Isoprene

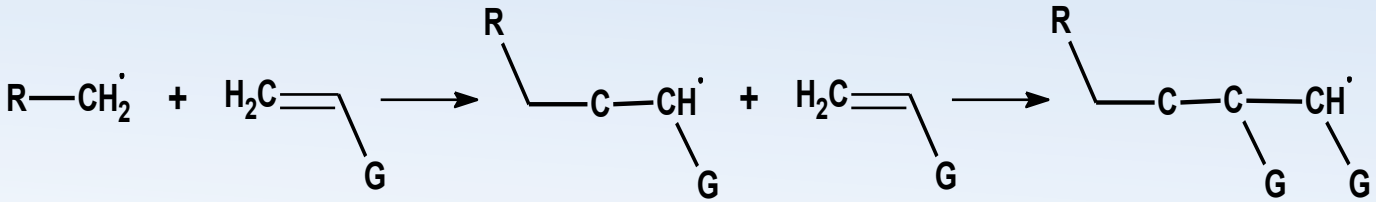
Imaging Process
Cross-link Reaction

Chemical Develop
Cross-link Patterns
Remain w/Neg Slope





Free Radical Generation



Polymer crosslinking

Lifts Off Negative PR

Conventional Organic Solvents

- PR removal for bumping processes normally done w/ solvent systems
- Solvent systems can be higher cost
- Solvent systems can contain DMSO, high odor
- Most solvents generate waste
- Some solvents toxic, becoming regulated

DaeClean – Aqueous PR Stripper for Bumping

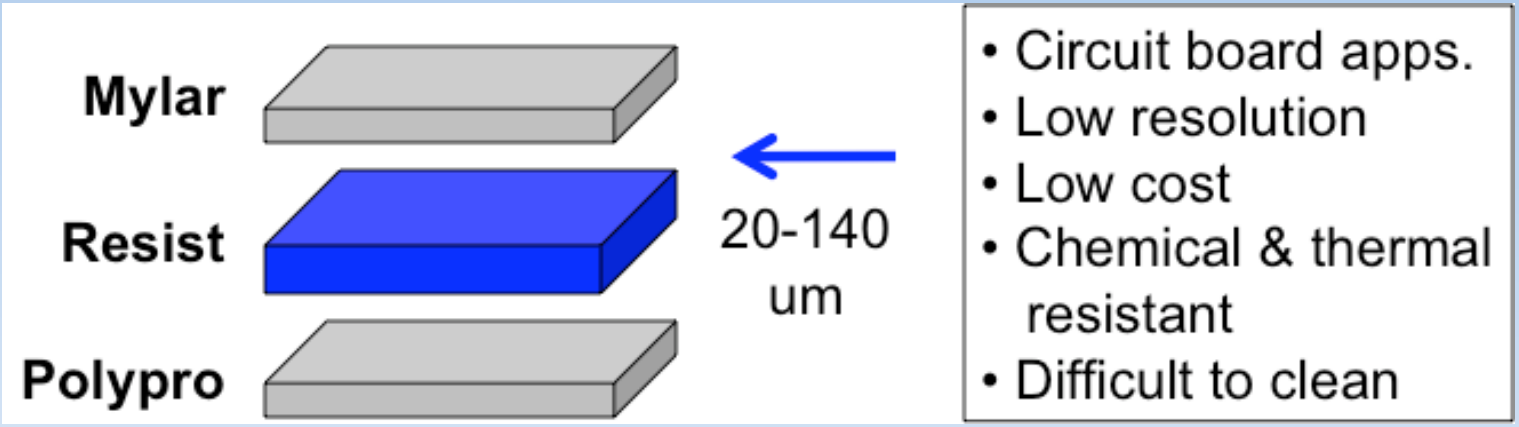
- DaeClean is a robust aqueous cleaner
- Exhibits high metal safety
- Low-surface tension, rinses easily
- No Odor (Non-DMSO), Non-regulated
- Pos-Tone PR is removed by dissolving
- Neg- Tone PR is removed by lift-off

Metal Safety

Chemistry	Al	Cu	Ni	Sn	Pb	Ti
DIW	24	0	0	0	11	0
Competitor HA	2769	30	1	27	124	4
Competitor Semi-Aqueous	1060	6	0	17	17	6
Competitor Non-Aqueous	29	3	0	2	28	6
DaeClean	10	<1	5	<1	<1	0

***Etch Rates = Angstroms/minute**

Negative PR Forms



- Negative PR is available in liquid and dry film
- Cross-linked neg PR is difficult to remove
- DaeClean lifts-off PR from the substrate

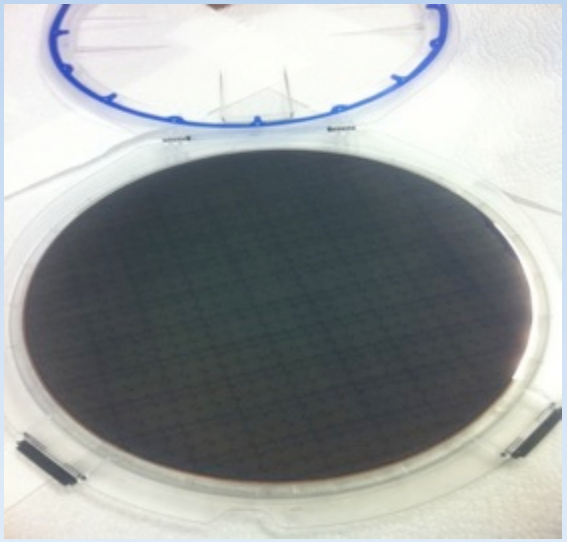
PR Lift-Off

Coated Disk | Chemical Exposure | Cleaned Substrate

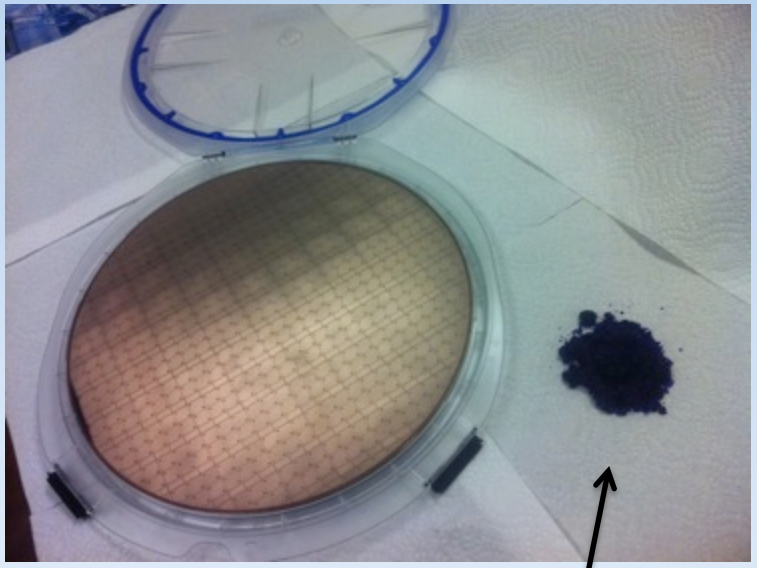
Particles are small
Filtered by 100um
Bag filter or similar

1 12” wafer yields ~8 g PR

PR Lift Off



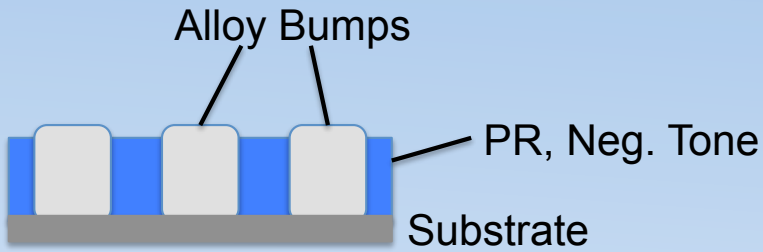
Before Cleans
PR covers wafer



After
PR Removed

PR is lifted from wafer, filtered, collected, disposed as trash

Solvent Systems Slower Cleans for Neg PR



Solvent Performance

Slow Dissolving

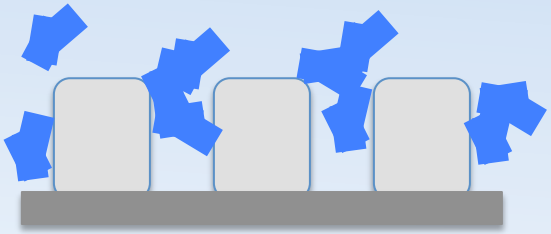
Time, 5min
PR reduced 5%

10min
5-10%

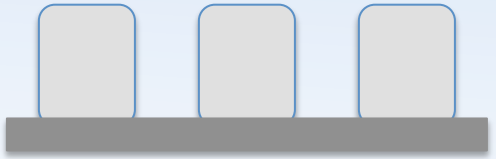
45min
60%

DaeClean Performance

Rapid Lift-Off



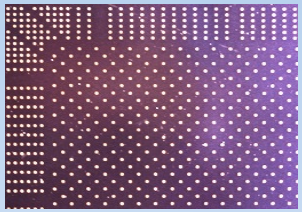
5min
Lift-off
80%

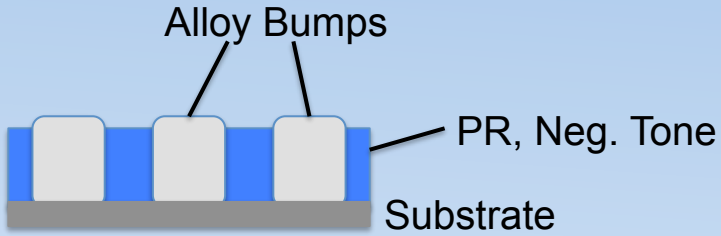


10-15 min
Clean

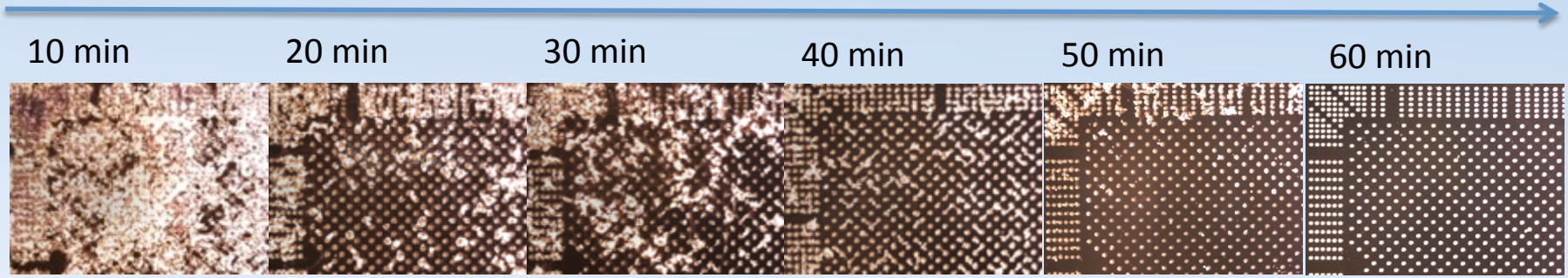
Solvents Are Slower for Neg PR

Untreated



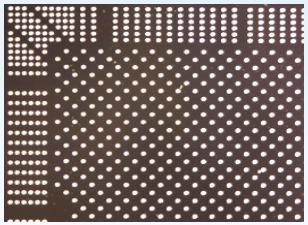


Organic Solvent Performance: 75C

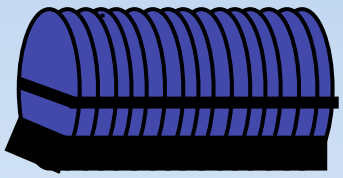


DaeClean : 75C

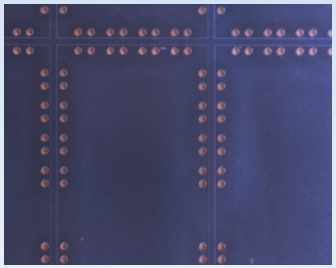
15 Min, Clean

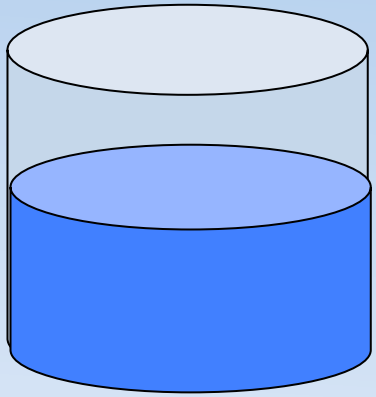


Performance – PR Removal Conditions



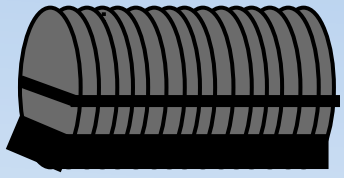
Wafers
w/ PR



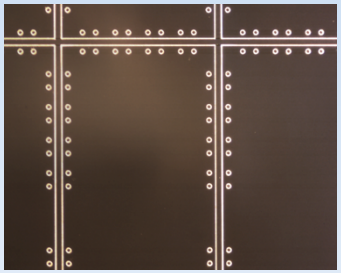


Aqueous Stripper,
<15 min, 75C

Rinse
DIW
IPA

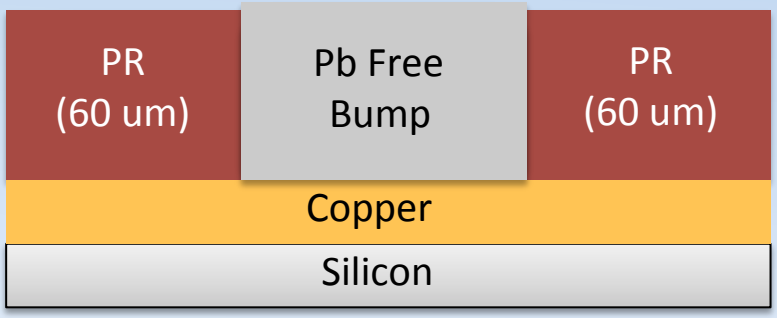


Wafers Clean

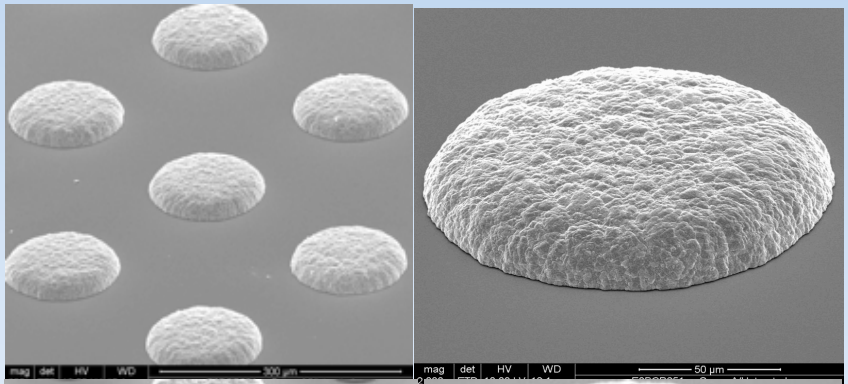


Positive PR Performance

Wafer Diameter	Metal	PR Tone	PR Form	PR Type	PR Thickness
300 mm (12 inch)	Cu UBM, Pb Free Mushroom Bumps	Pos. Tone	Liquid	AZ P4620 (Merck)	60 um

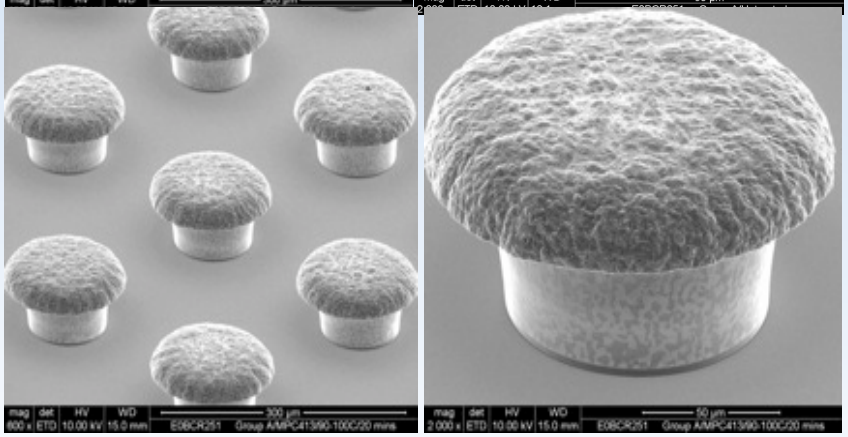


Untreated



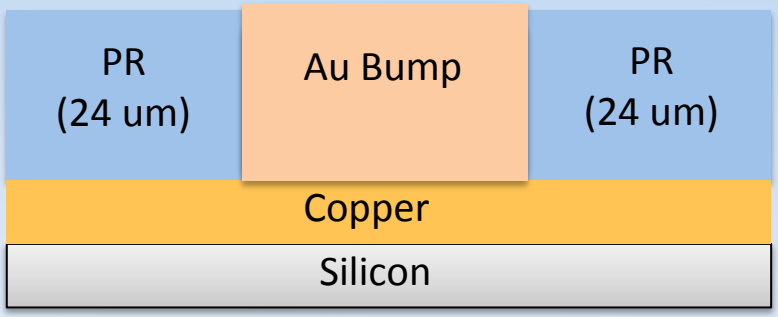
DaeClean
<15 min, 75C
Clean

Removes By Dissolving

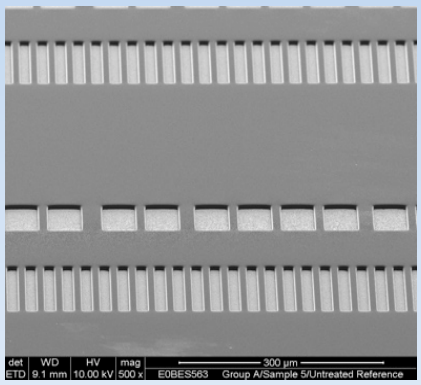


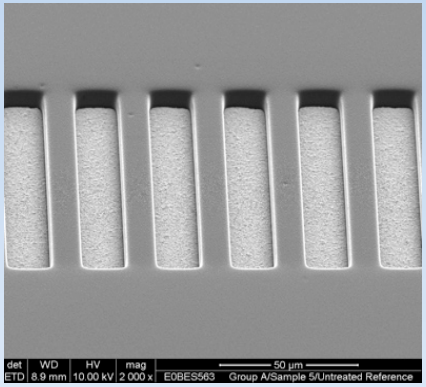
Negative Liq. PR Performance

Wafer Diameter	Metal	PR Tone	PR Form	PR Type	PR Thickness
200 mm (8 inch)	Cu UBM, Au Bumps	Neg. Tone	Liquid	THB-151N (JSR)	24 um



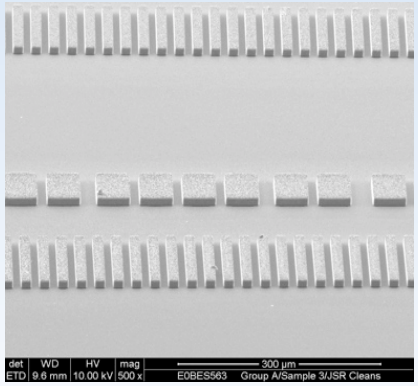
Untreated

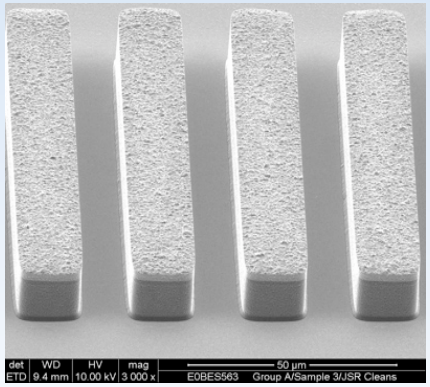




DaeClean
<15 min, 75C
Clean

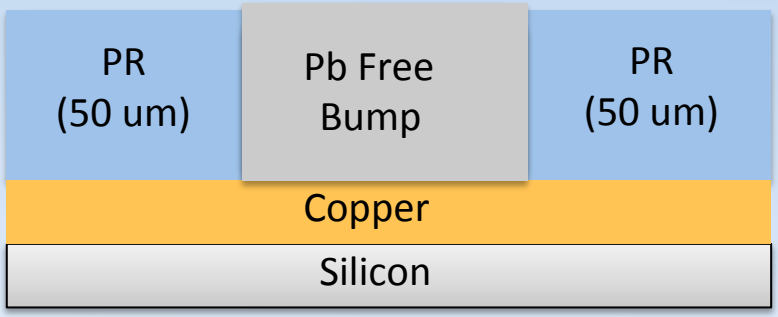
Removes By Lift Off



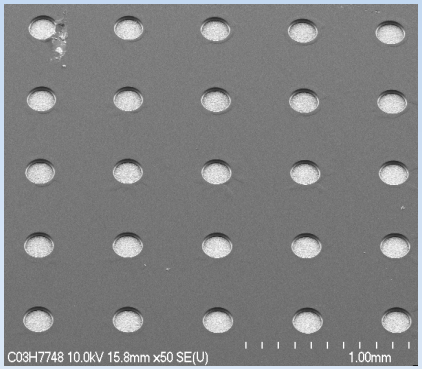


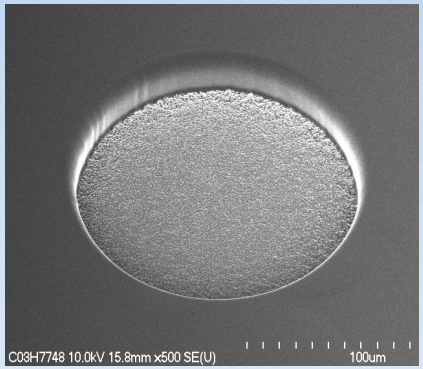
Negative Liq. PR Performance

Wafer Diameter	Metal	PR Tone	PR Form	PR Type	PR Thickness
200 mm (8 inch)	Cu UBM, Pb Free Bumps	Neg. Tone	Liquid	BPR-100 (Dow)	50 um



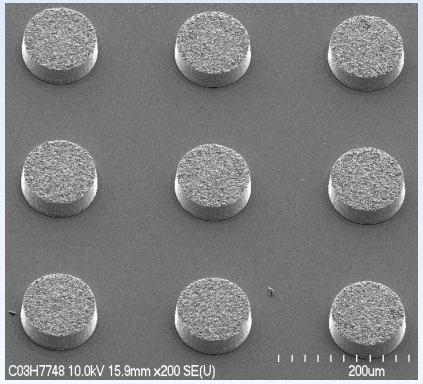
Untreated

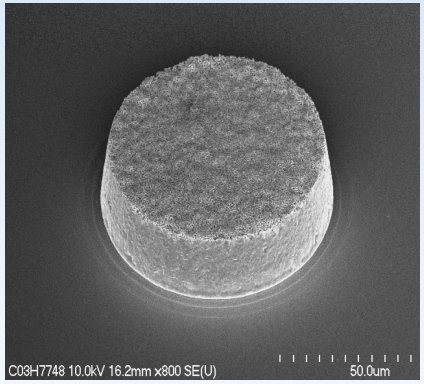




Aqueous Stripper
<15 min, 75-90C
Clean

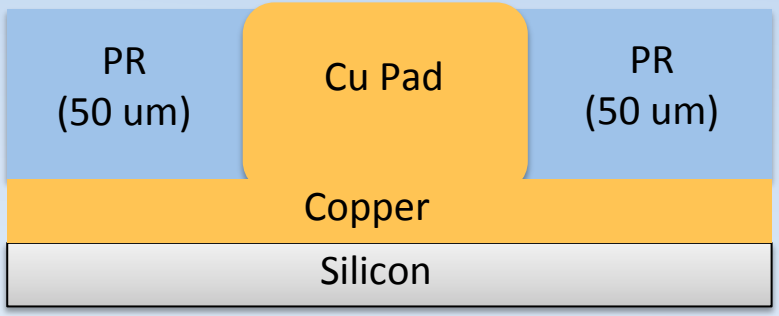
Removes By Lift Off



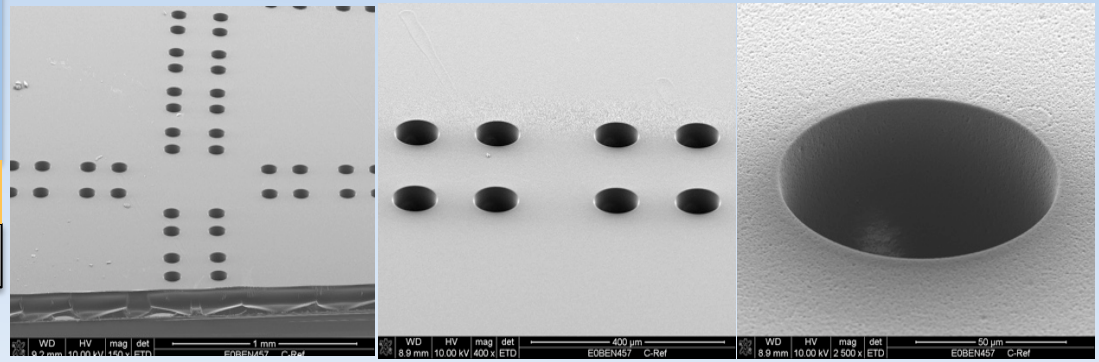


Negative DF PR Performance

Wafer Diameter	Metal	PR Tone	PR Form	PR Type	PR Thickness
200 mm (8 inch)	Cu UBM, Cu Pads	Neg. Tone	Dry Film	Unknown (Asahi)	50 um

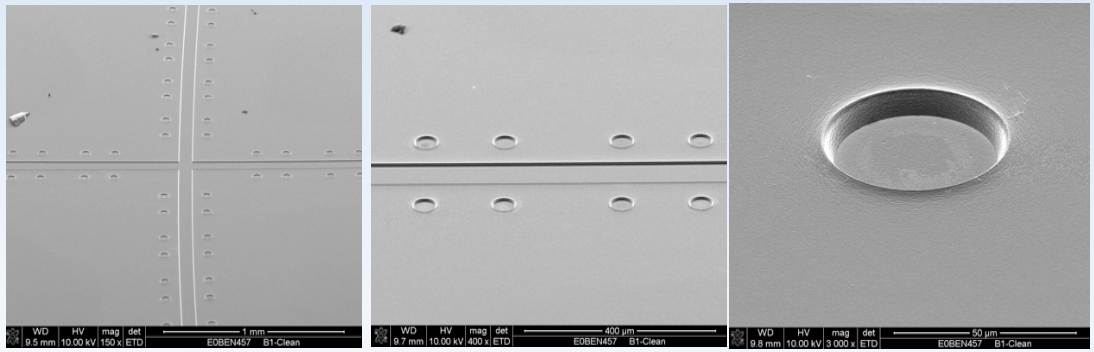


Untreated



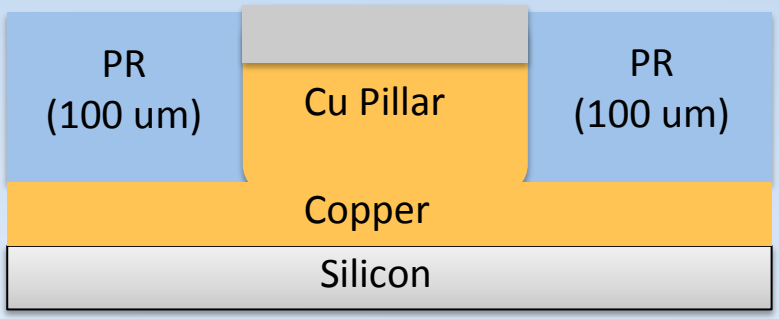
DaeClean
<15 min, 75C
Clean

Removes By Lift Off

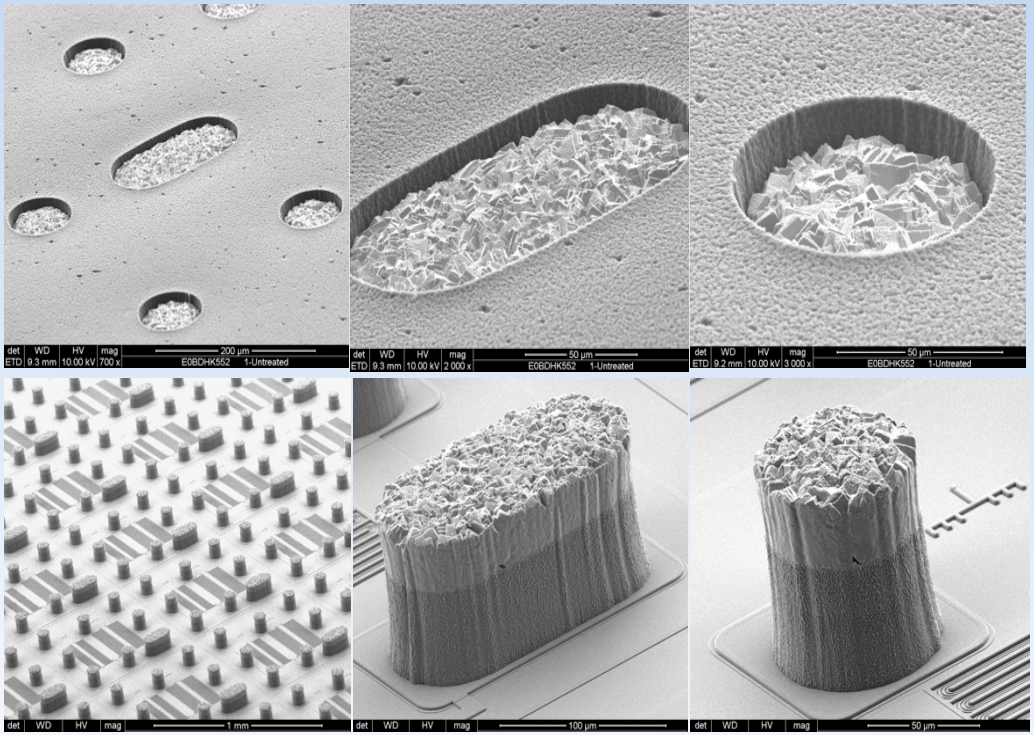


Negative DF PR Performance

Wafer Diameter	Metal	PR Tone	PR Form	PR Type	PR Thickness
150 mm (6 inch)	Cu UBM, Cu Pillar, Elongated Bumps	Neg. Tone	Dry Film	Unknown (DuPont)	100 um



Untreated

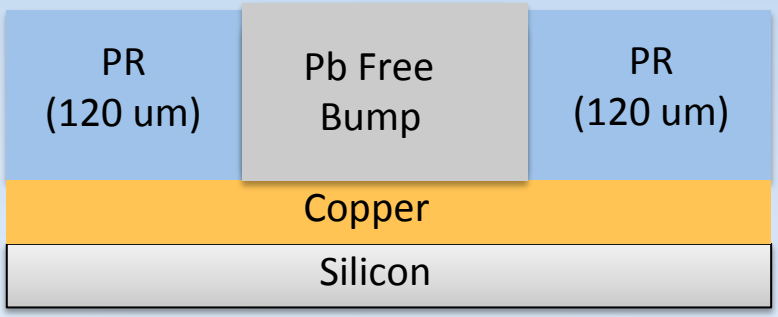


Aqueous Stripper
<15 min, 75-90C
Clean

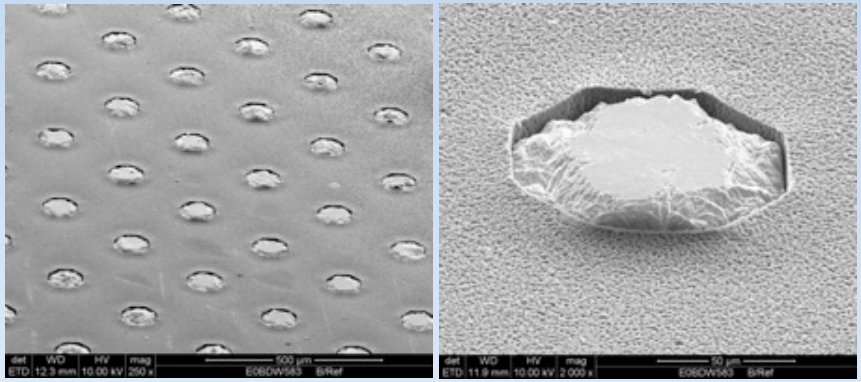
Removes By Lift Off

Negative DF PR Performance

Wafer Diameter	Metal	PR Tone	PR Form	PR Type	PR Thickness
300 mm (12 inch)	Cu UBM, Pb Free Cylindrical Bumps	Neg. Tone	Dry Film	Unknown (TOK)	120 um

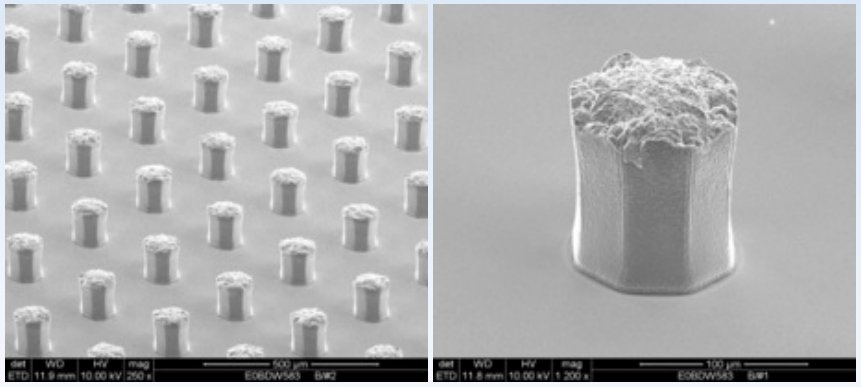


Untreated



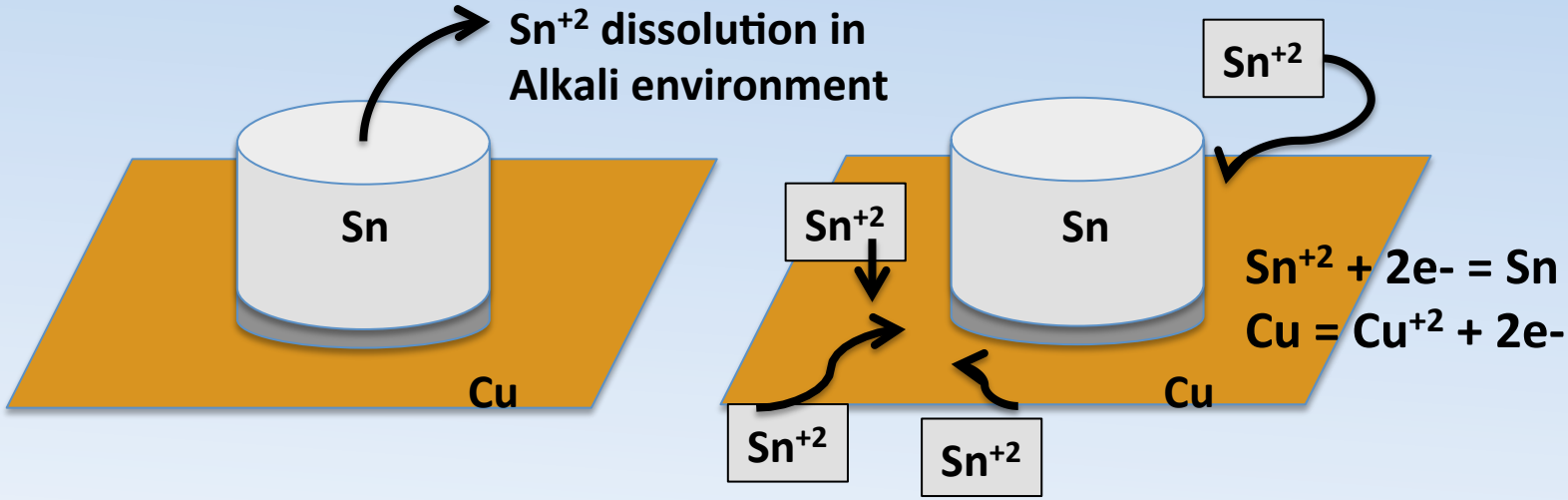
Aqueous Stripper
<15 min, 75-90C
Clean

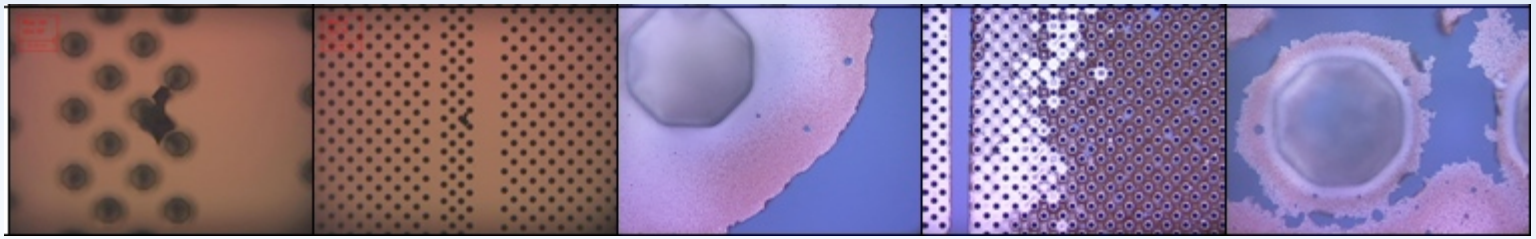
Removes By Lift Off



Cu Etch Performance

- Aqueous Strippers, if not optimized, can produce galvanic corrosion, affecting Cu etch step

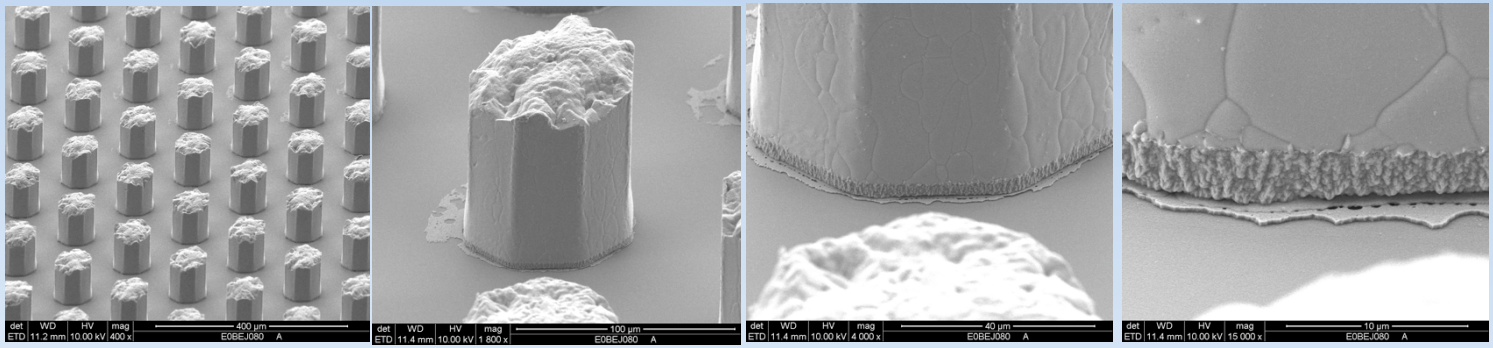




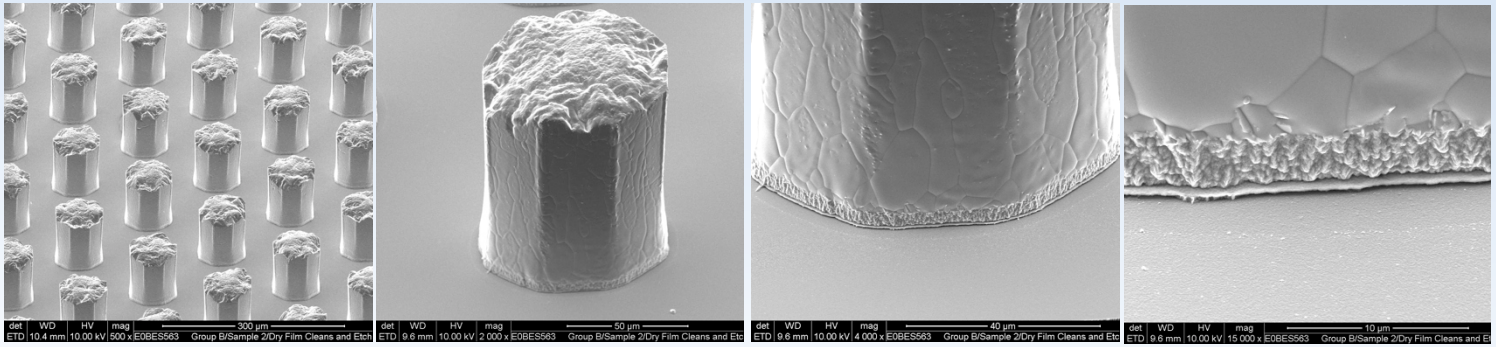
DaeClean Inhibitor Performance

Cu-Etch

- DaeClean Without Inhibitor – Incomplete Cu Etch, Residue



- DaeClean With Inhibitor – Complete Cu Etch Clean



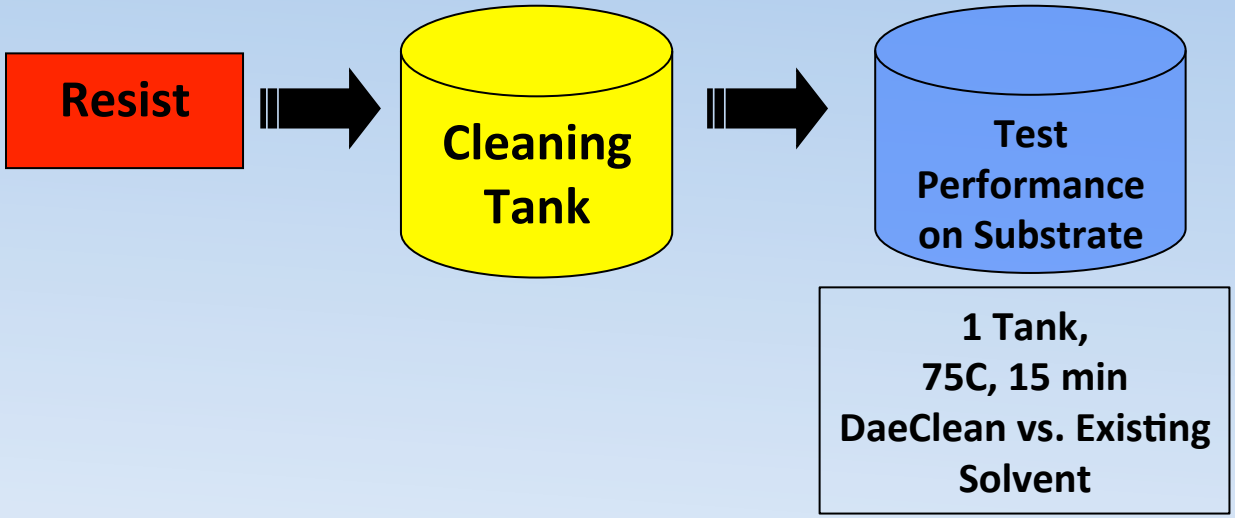
Bath Life Study

- Bath life: maximum # of substrates processed at specific conditions in a PR stripper tank of given volume
- Time, temperature, agitation directly affect bath life

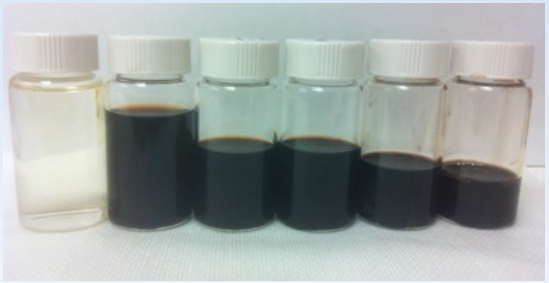
Bath Life - Method

- Load stripper chemistries with cured photoresist
  - Positive PR : AZ P4620 (MERCK)
  - Negative PR: THB-151N (JSR)
- Test PR removal performance for both aqueous DaeClean vs. existing solvents
  - Existing Solvent for Pos. PR: NMP Solvent
  - Existing Solvent for Neg. PR: TMAH in DMSO
- Calculate bath life using algorithm

Bath Life – Resist Loading



% PR to Load:	0	1.0	2.0	3.0	4.0	5.0
Pos/Neg Bath Life	Load 0 – 5% PR into Stripper Solutions					



Bath Life - Results

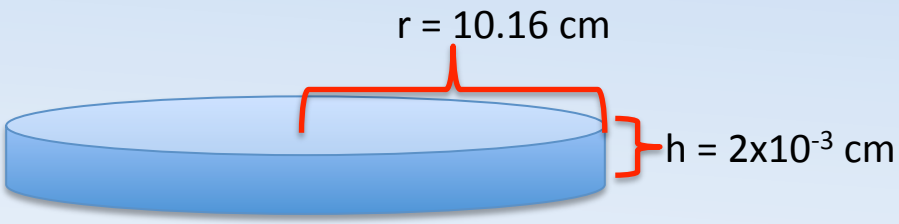
Stripper	PR Type	0% PR	1% PR	2% PR	3% PR	4% PR	5% PR
Solvent	Positive	Clean			Not Clean		
	Negative	Clean		Not Clean			
DaeClean	Positive	Clean				Not Clean	
	Negative	Clean				Not Clean	

Process conditions: 75C 15 min

Converting % PR to Bath Life (WPG)

- **For Stripper and PR Assume 1 g = 1 cm^3 = 1 mL**
- Using wafer specs, determine volume of PR per wafer ($V = \pi * r^2 * h$)

Units	Wafer Diameter	Wafer Radius	PR Thickness	PR Volume
cm	20.32 cm	10.16 cm	0.002 cm	0.649 cm^3



8" Wafer w/ PR

$V_{PR} = \pi * r^2 * h$

$V_{PR} = \pi * (10.16cm)^{2*} (0.002cm)$

$V_{PR} = 0.649\ cm^3$ PR, per 1 wafer

$Mass_{PR} = 0.649$ g PR, per 1 wafer

(Assuming 100% PR Coverage)

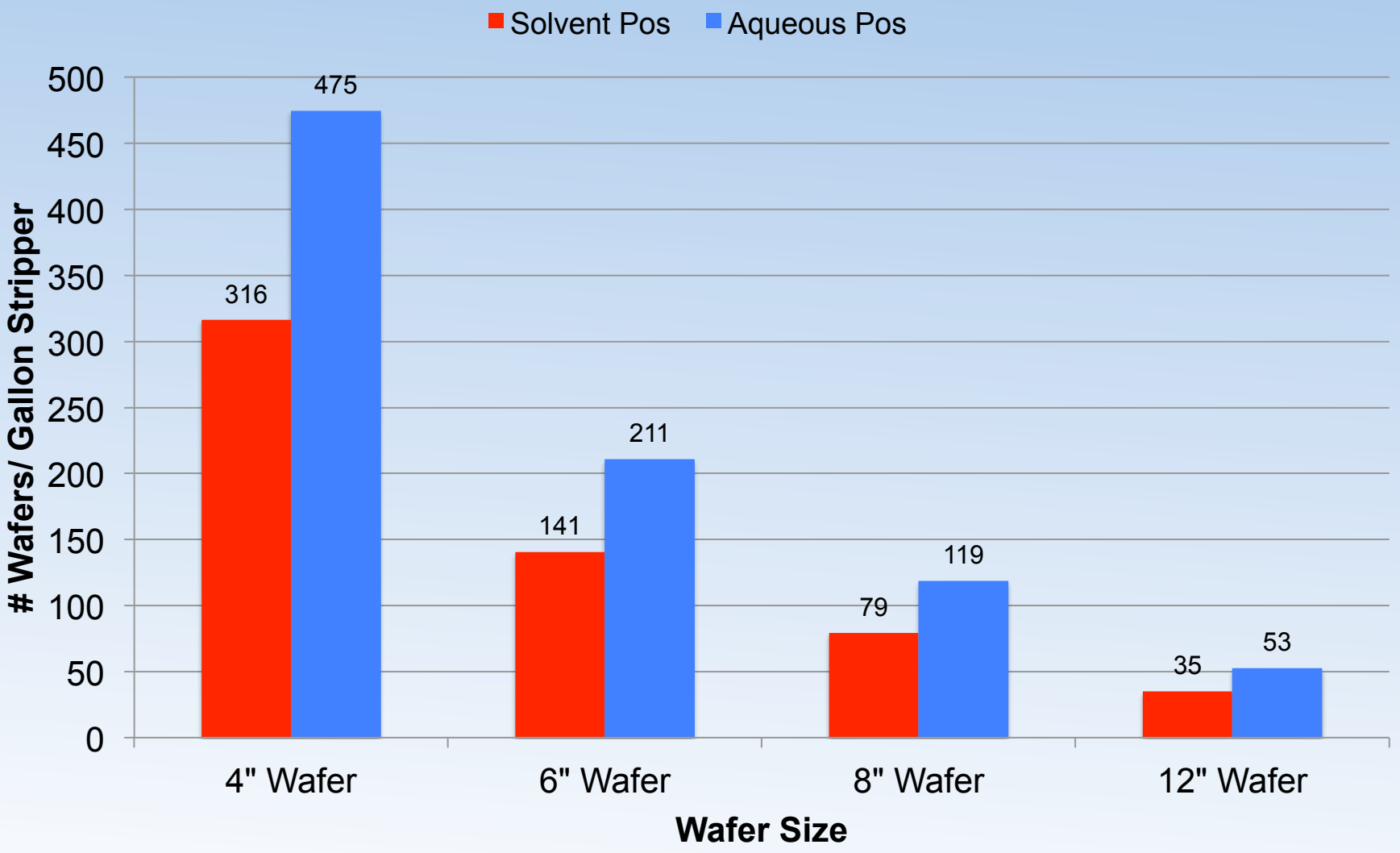
Bath Life Conversion: % PR to WPG

- WPG = Wafer per Gallon (Bath Life)

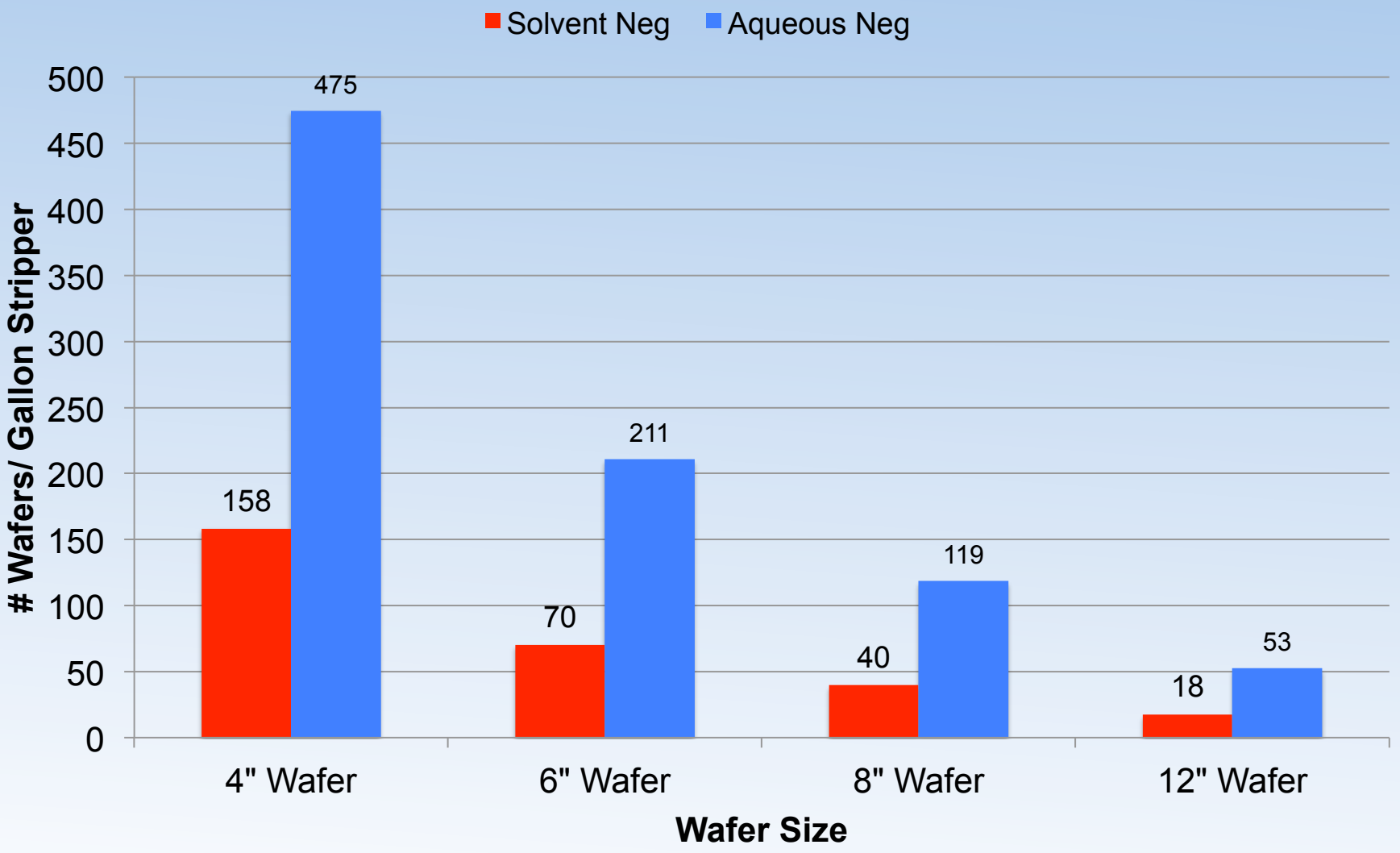
$$WPG = \left(\frac{X\,g\,PR}{100\,g\,Stripper}\right) \times \left(\frac{1\,wafer}{0.649\,g\,PR}\right) \times \left(\frac{100\,g\,Stripper}{0.026\,gal\,Stripper}\right)$$

X value Based on % PR loaded in solution

WPG vs. Wafer Size – Positive PR



WPG vs. Wafer Size – Neg PR

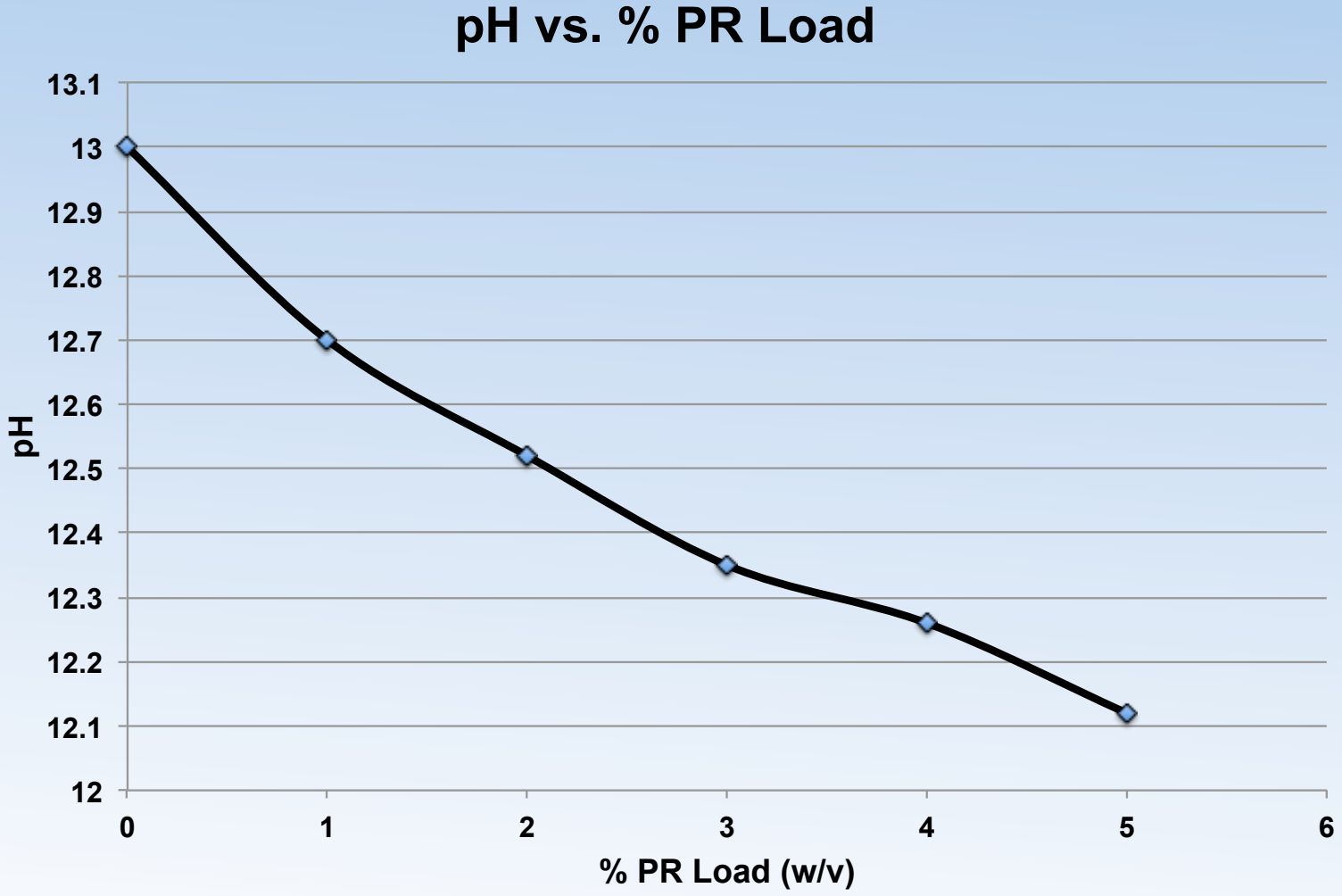


Bath Monitors

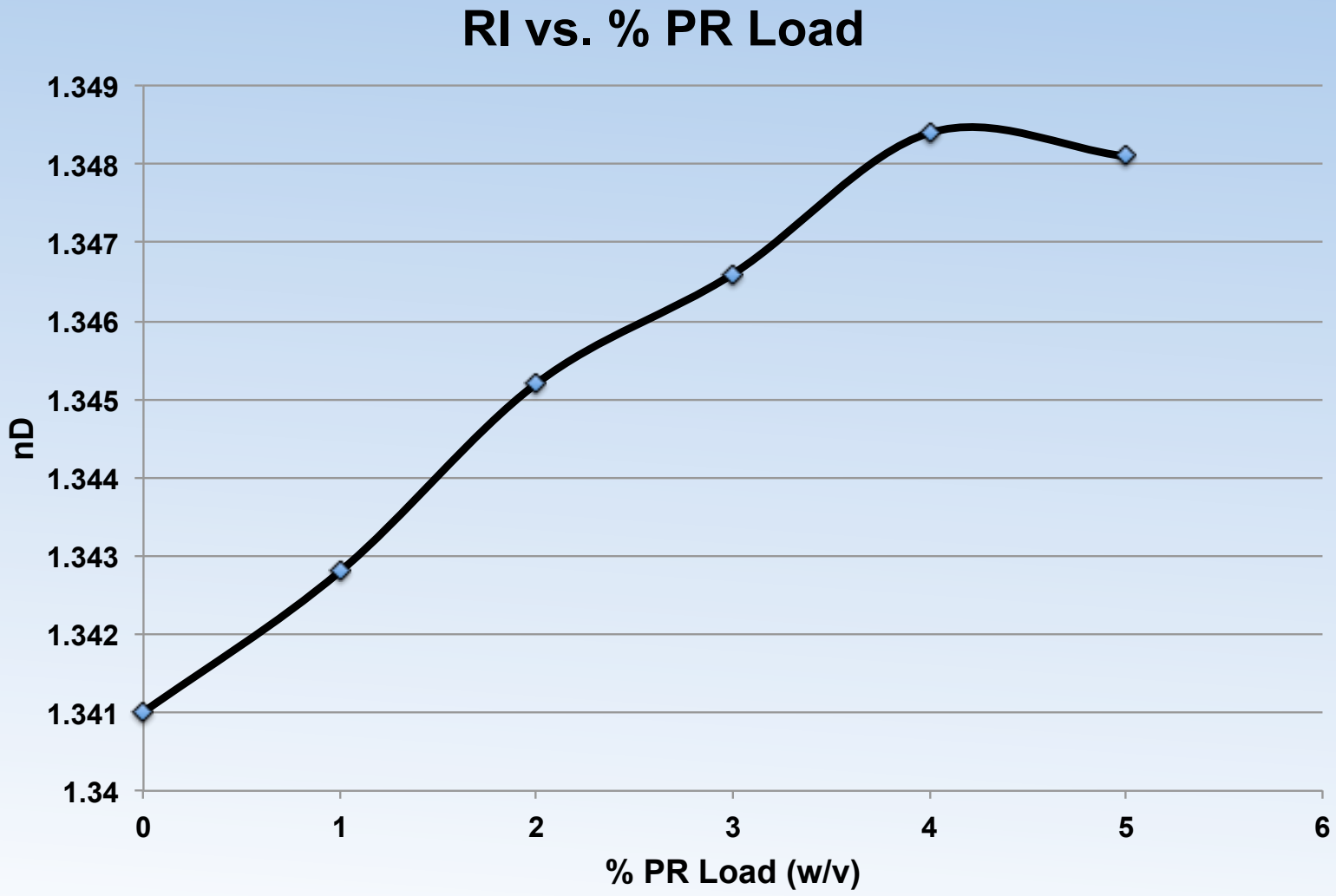
pH Probe
In-line
Equipment
Is available

Refractometer
Varying sensitivity
Meters available

pH drop with PR Loading



RI Rise with PR Loading



DaeClean is GREEN

- Alkali stripper diluted in WATER
- Safe for workers (no solvent vapor)
- Removed/filtered PR is plastic trash
- No solvent waste
- No odor (no DMSO/sulfur) – meets local municipal waste objectives
- Liquid waste is simply treated & sewered

10. Summary

- Aqueous detergent uses DIW as PR stripper
- Corrosion control is excellent with DaeClean
- High bath life is achieved for both pos and neg PRs used for bumping
- As designs change to pillar architecture, aqueous cleans is a better match vs solvents
- Elimination of risks and reduction of costs is possible using aqueous cleaning technologies

Contact for More Information

- DAETEC provides development, consulting, and technical training/support to solve manufacturing problems and introduce new options of doing business.
- Diversified Applications Engineering Technologies (DAETEC)

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