

Development of Post CMP Cleans for Advanced Node Challenges

May 15, 2013



Contents

1. Introduction

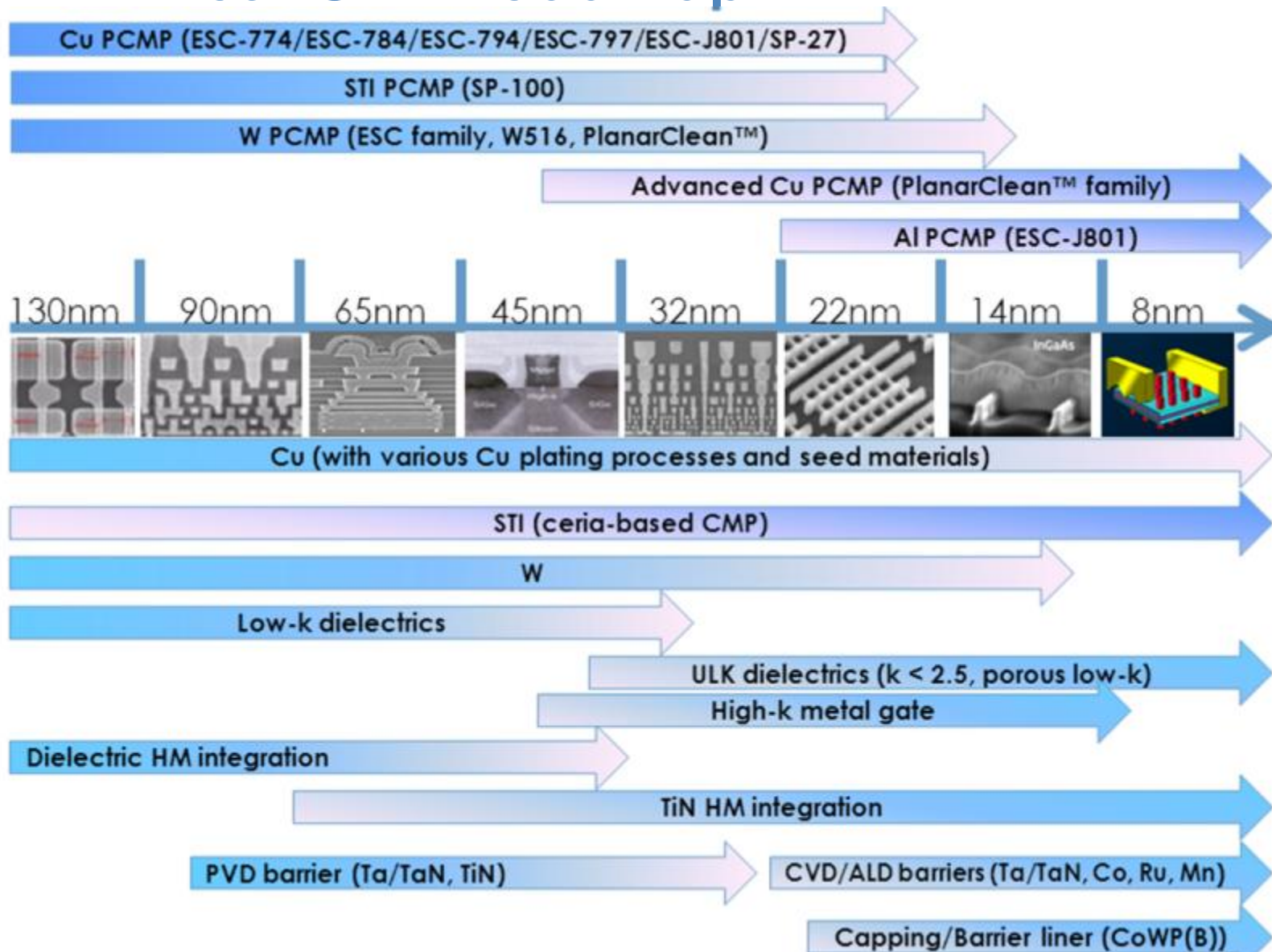
- 1) Roadmap of ATMI's post CMP formulations.

2. Post CMP formulation development

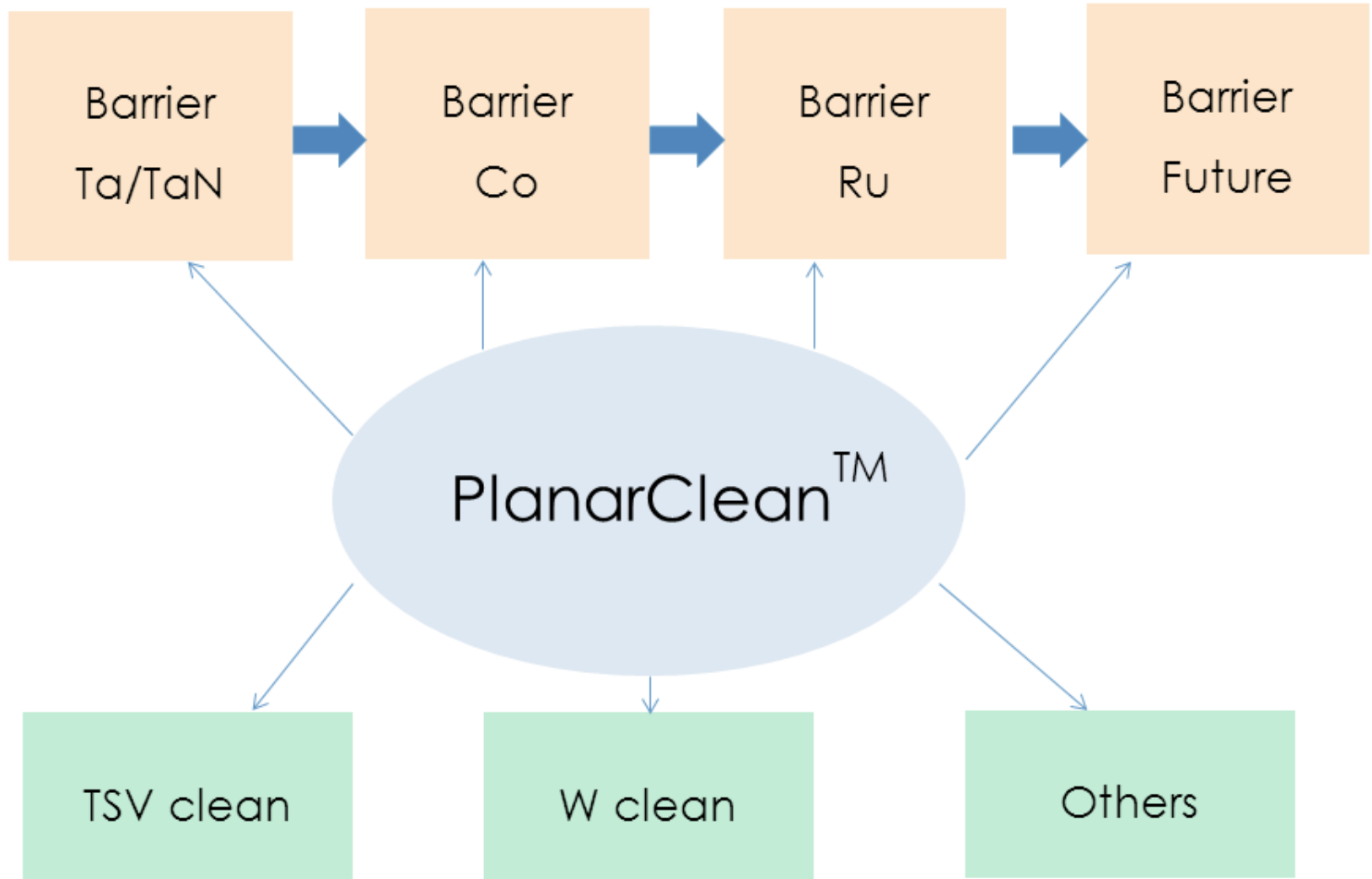
- 1) PlanarClean™
- 2) Post CMP formulation with cobalt compatibility
- 3) Post CMP formulation with ceria particle removal

3. Conclusions

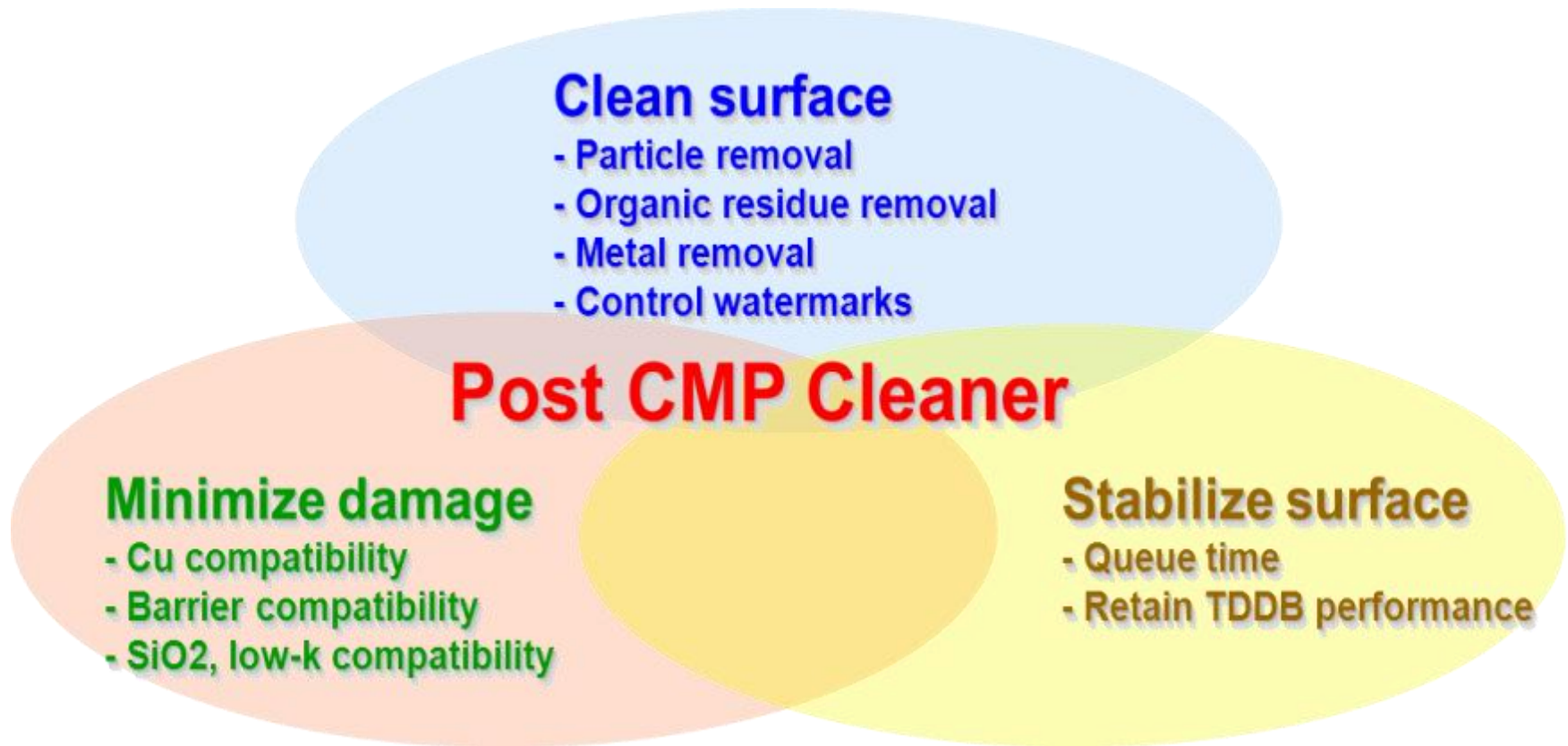
ATMI Post-CMP Roadmap



PlanarClean™ for advanced nodes



Alkaline PCMP formulation: PlanarClean™



Targeted at all new customers for Cu PCMP and, for existing customers at advanced technology nodes.

Post CMP formulations with Co compatibility

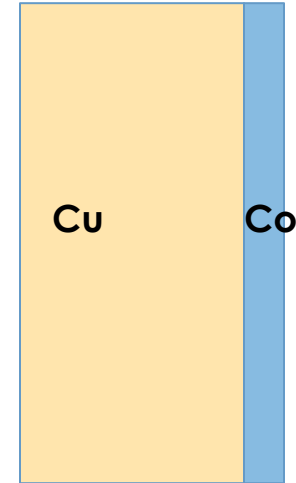
Standard reduction potential



For Cu-Co couple,

Cu is galvanically protected.

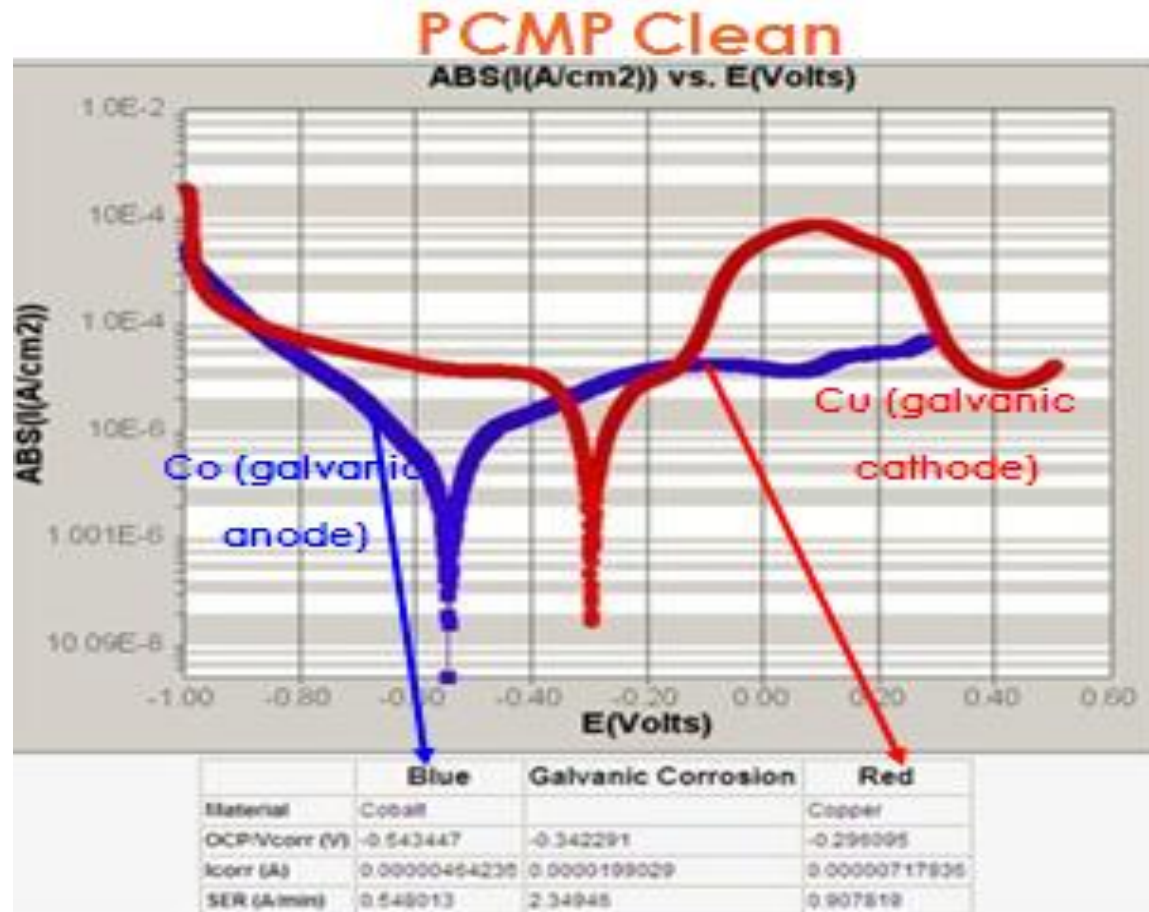
Co is galvanically corroded.



For post CMP formulation:

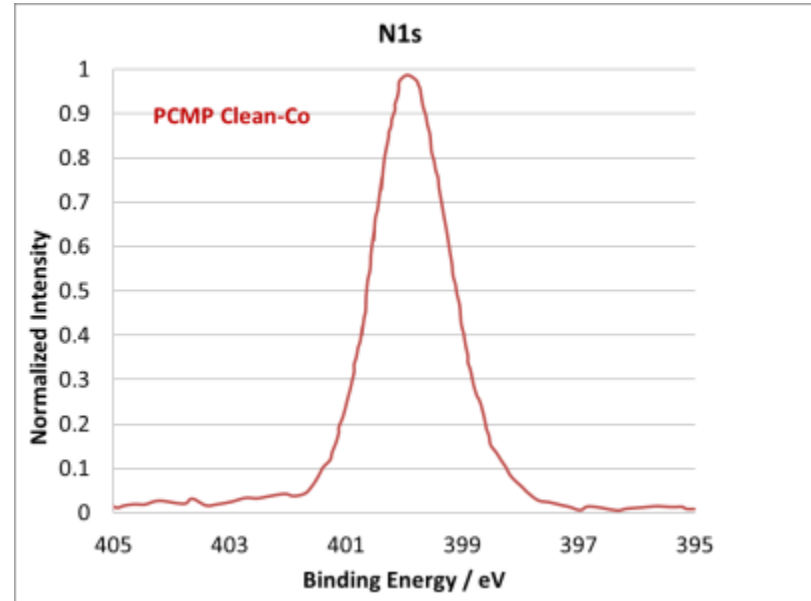
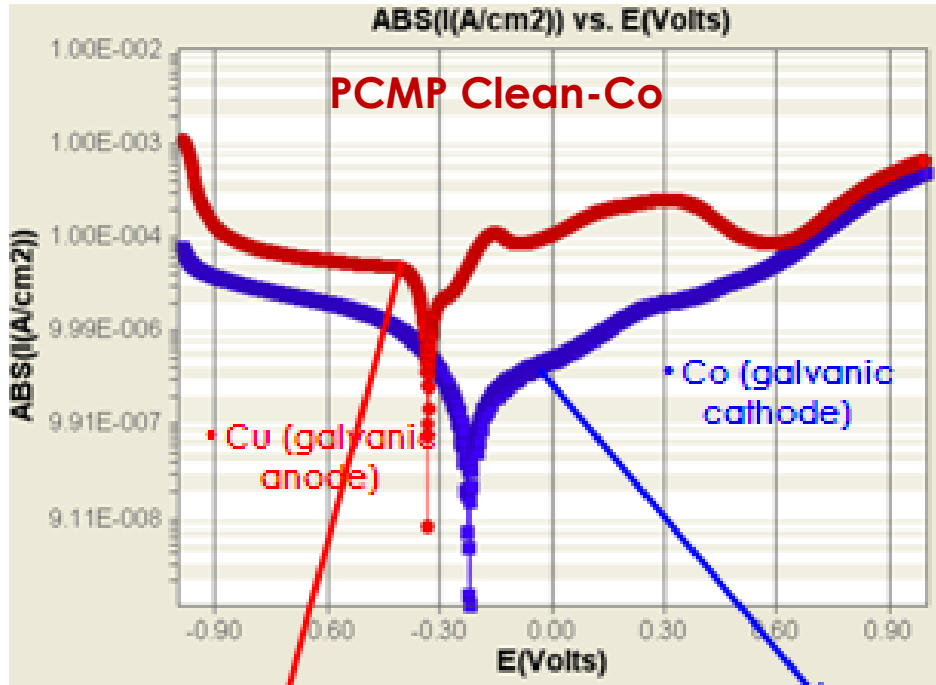
1. Decrease Co etch rates.
2. Make Co galvanic protected.

Development of Co-compatible formulation



1. Copper is cathodically protected.
2. Cobalt exhibits accelerated corrosion .

The effect of inhibitor on Co protection

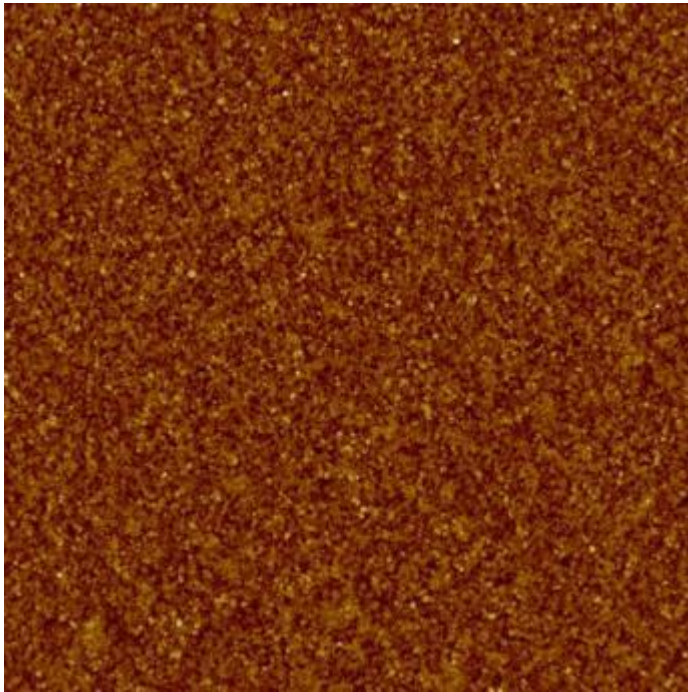


Material	Copper		Cobalt
OCP/V _{corr} (V)	-0.332653	-0.326937	-0.217994
I _{corr} (A)	0.0000219291	0.00000519293	7.95314e-7
SER (A/min)	2.77290	0.656637	0.0938839

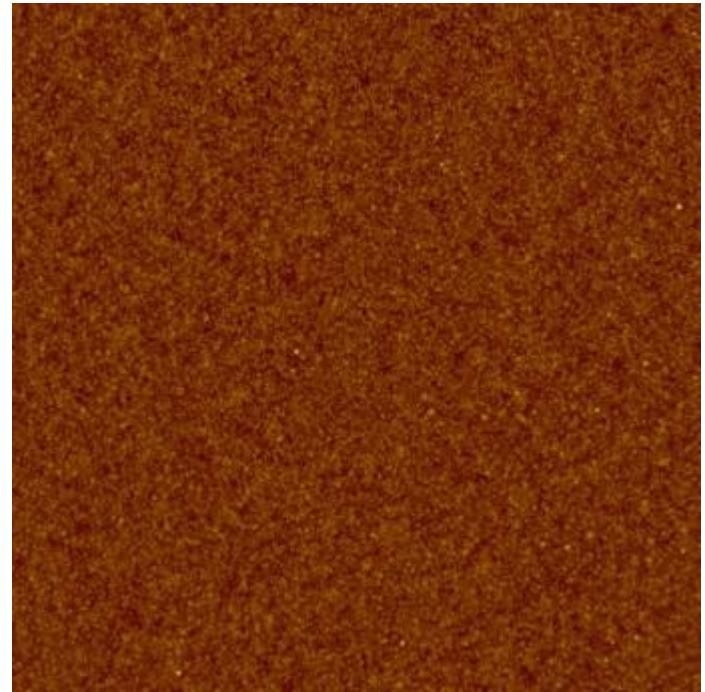
XPS spectra of Co surface

1. The inhibitor resulted in decrease in Co corrosion rate.
2. Co was also galvanically protected.
3. An inhibitor layer was formed on Co surface.

AFM images of Cu surface after Formulation Treatment



PCMP Clean



PCMP Clean-Co

1. The PCMP Clean-Co was not only cobalt compatibility, but also showed similar smooth Cu surface.
2. The cleaning performance was also confirmed by whole wafer tests from customers.

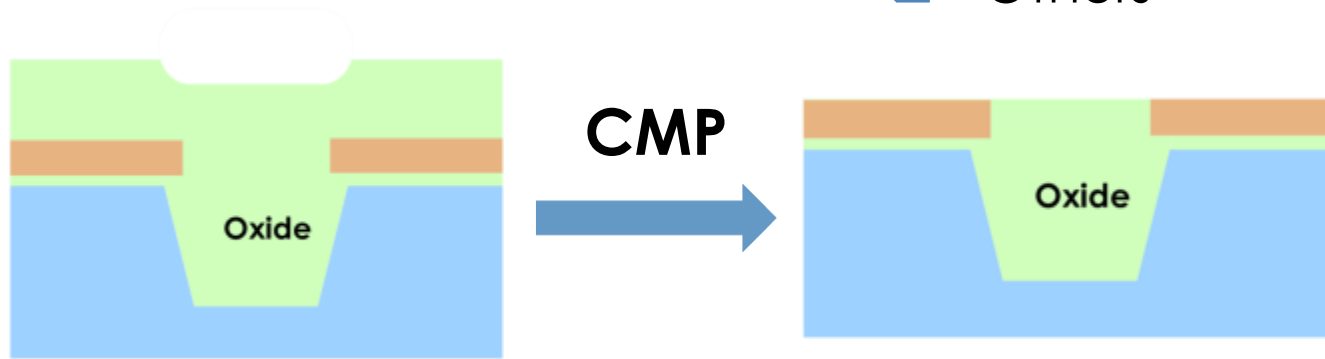
PCMP cleaning for ceria from silicon oxide CMP process

CMP process using ceria slurry:

- ❑ Shallow Trench Isolation
- ❑ FinFET

Commercial process

- ❑ DHF
- ❑ Ammonia
- ❑ Others



Shallow Trench Isolation

Defects after ceria CMP process

- ❑ Ceria particles
- ❑ Metal ions.
- ❑ Scratches

Post CMP cleaning for removing ceria particles

Challenges for post CMP cleaning of ceria particle:

1. No damage of silicon oxide surface.
2. High removal efficiency for ceria particles.
3. No metal impurities left on surface.

Difference between silica particles and ceria particles in slurry

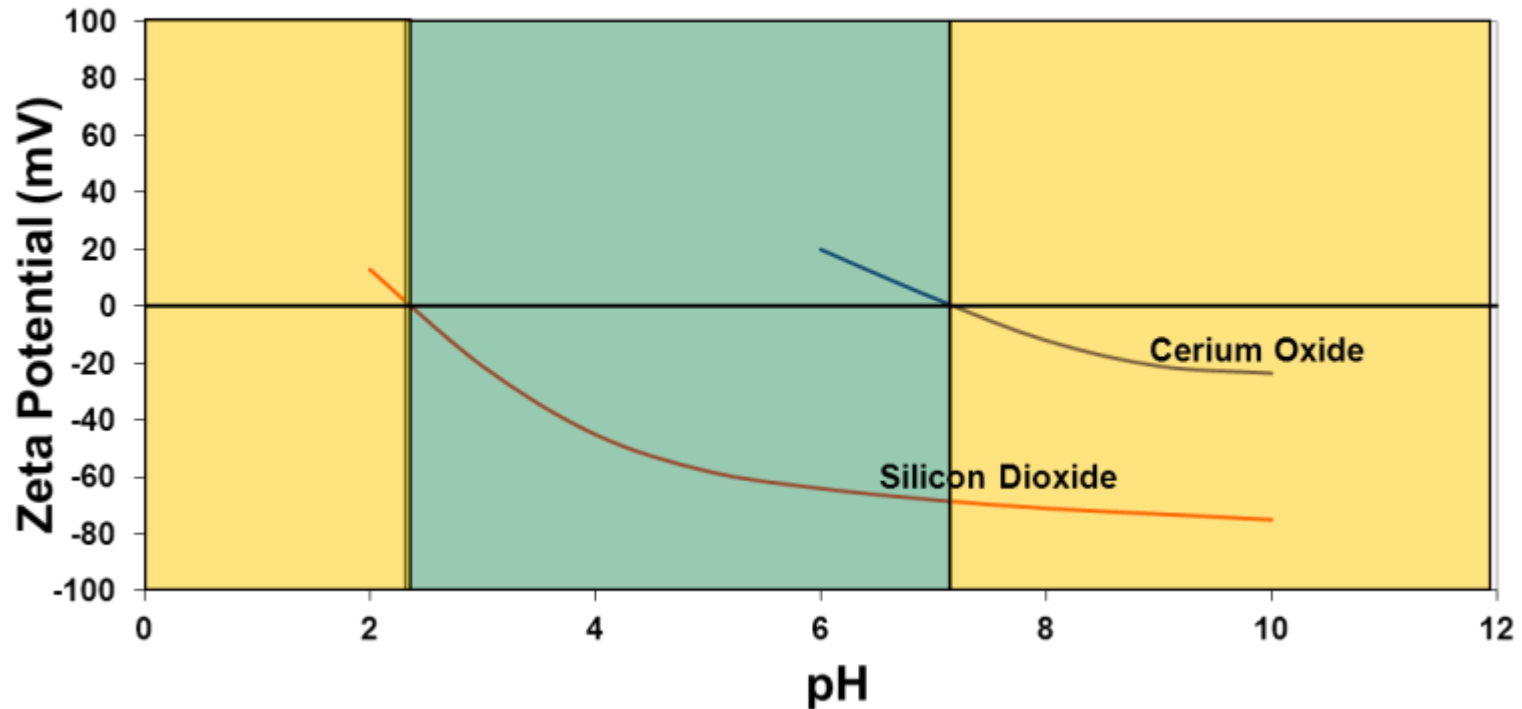
1. Ceria has redox properties.
2. Cerium is heavier than silicon (atomic weight 140 vs. 28)
3. The size of ceria particle is larger than silica particles.

Formulation objective

Develop a post CMP formulation that has high efficiency for ceria particle removal and no effect on silicon oxide substrate.



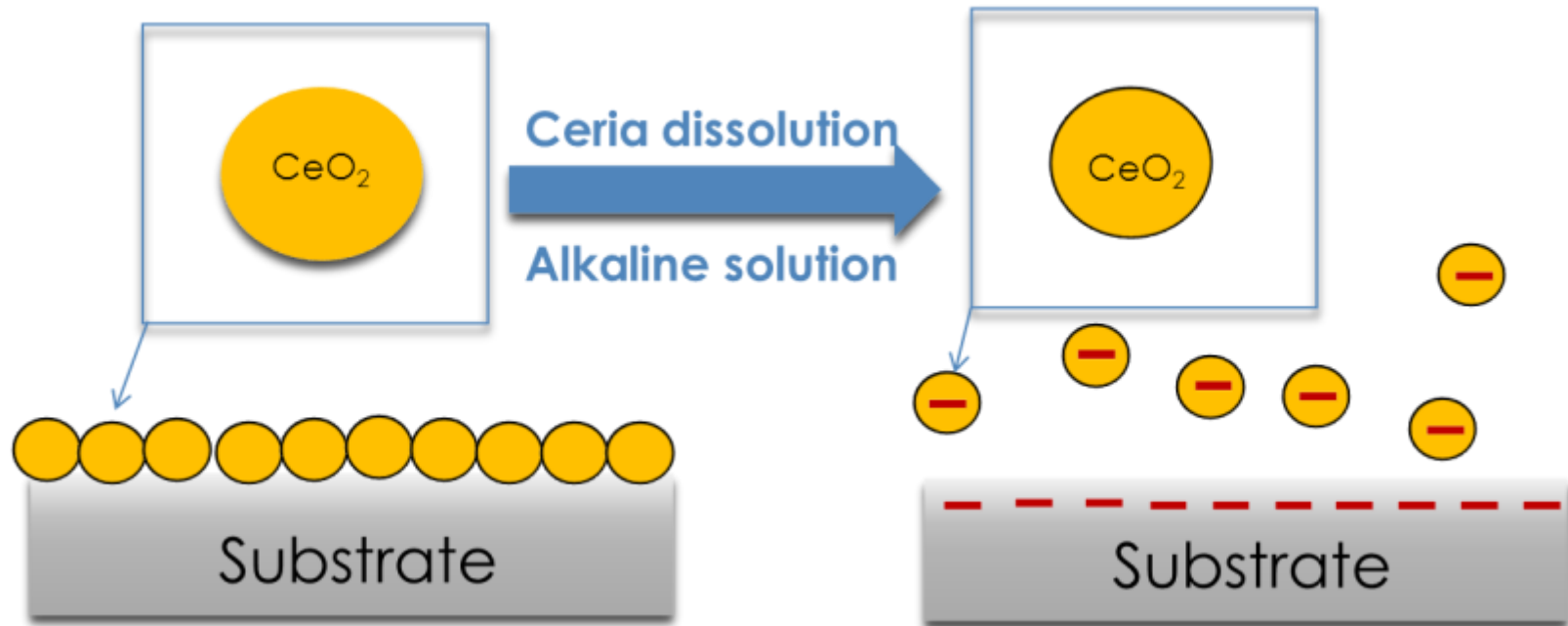
Zeta Potential for ceria and silica particles



Ceria particle and silicon dioxide in alkaline solutions:

1. Both had negative zeta potential.
2. The zeta potential for ceria particles was less negative.

Post CMP cleaning for ceria particle removal



- > Ceria particles were partially dissolved and then cleaned.
- > No damage of the substrate.
- > No metal ions left on the substrate.

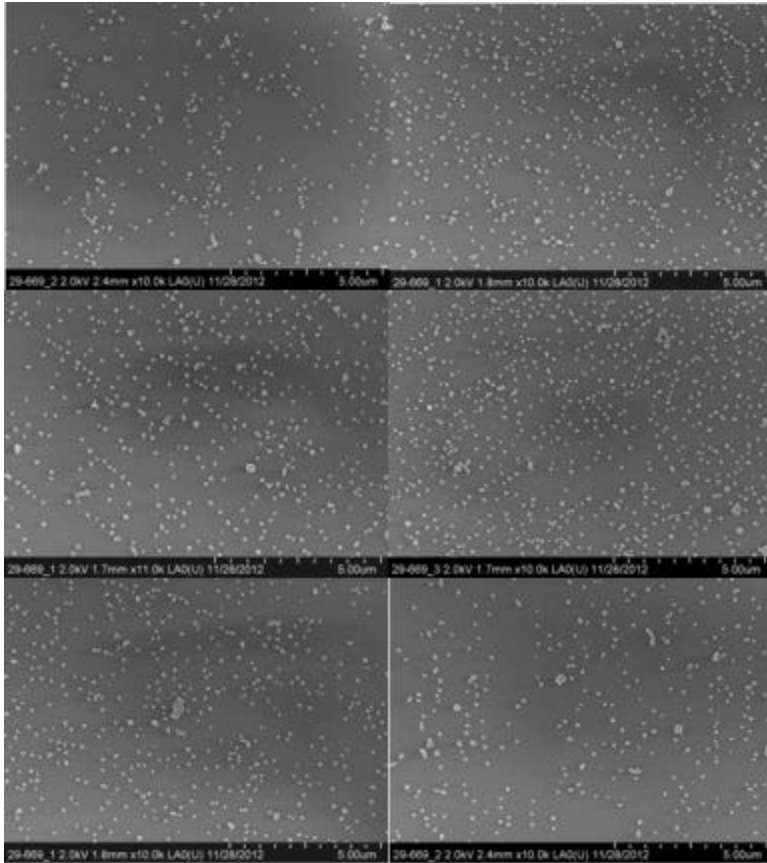
Ceria dissolution in post CMP formulation



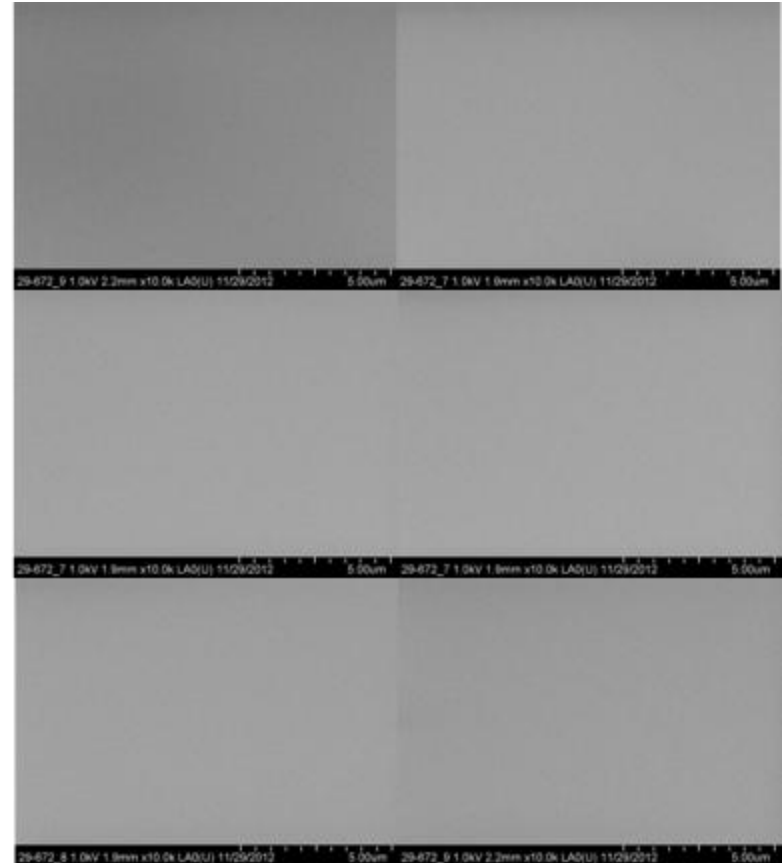
Formulations	2% NH ₃ .H ₂ O	SP100	Formulation-1	Formulation-2
% ceria dissolved	0.0000	0.0004	0.0012	0.0030

1. All formulations were tested at dilution ratio of 60:1.
2. Commercial ceria particles were used.
3. Ceria dissolution could be controlled.

Cleaning of ceria particles from TEOS surface



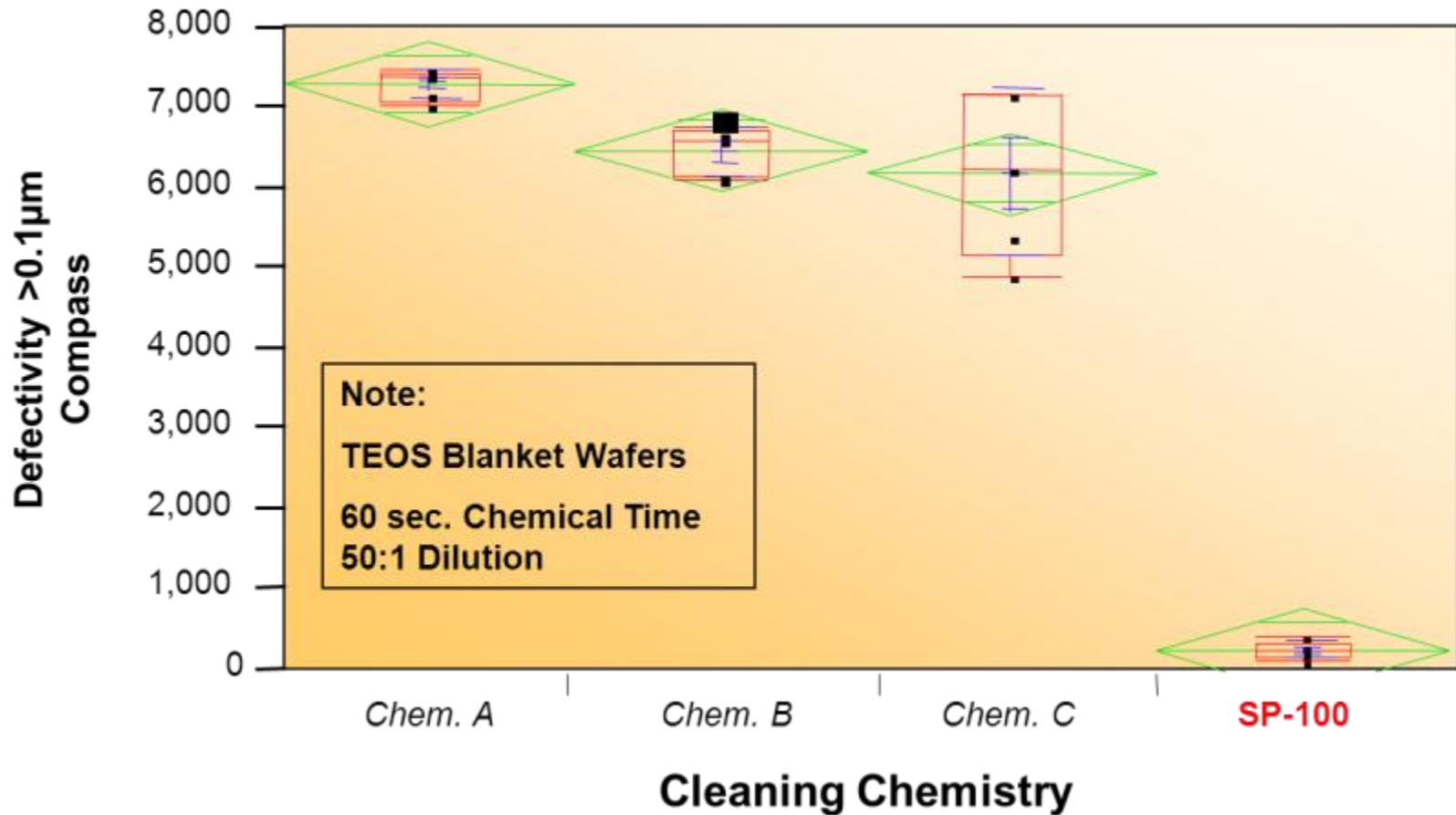
Ceria particles on surface



Cleaning by SP100 (60:1)

1. Using Buehler benchtop polisher for cleaning tests.
2. The cleaning time was 15 sec followed by 10 sec rinse by water.

The cleaning performance of SP100 compared to other chemistries



Summary

1. ATMI's post CMP cleaning chemistry is # 1 in the semiconductor market and dominant in alkaline chemistry
2. ATMI's post CMP cleaning chemistry can be used in multiple advanced nodes as well as in multiple PCMP applications.
3. Post CMP formulations were developed for Co barrier layer and met the customer's need.
4. Post CMP formulations were developed for ceria particle removal without any substrate affects.





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