HOLISTIC APPROACH TO THE UNDERSTANDING CMP-INDUCED DEFECTS

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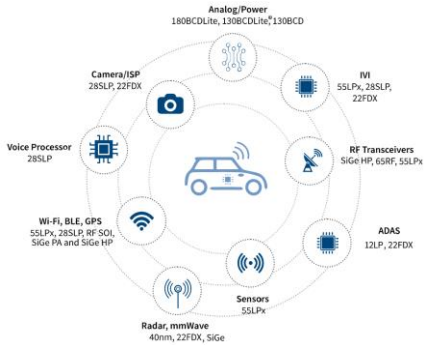

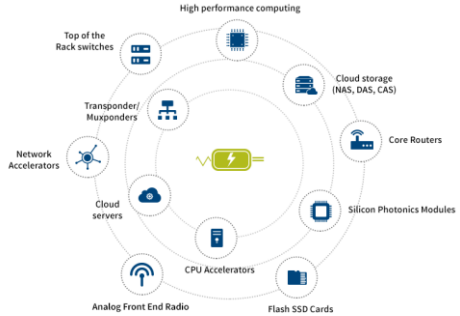

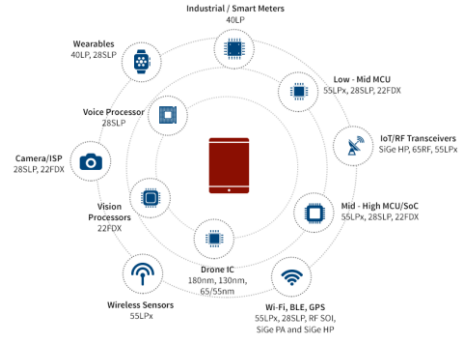

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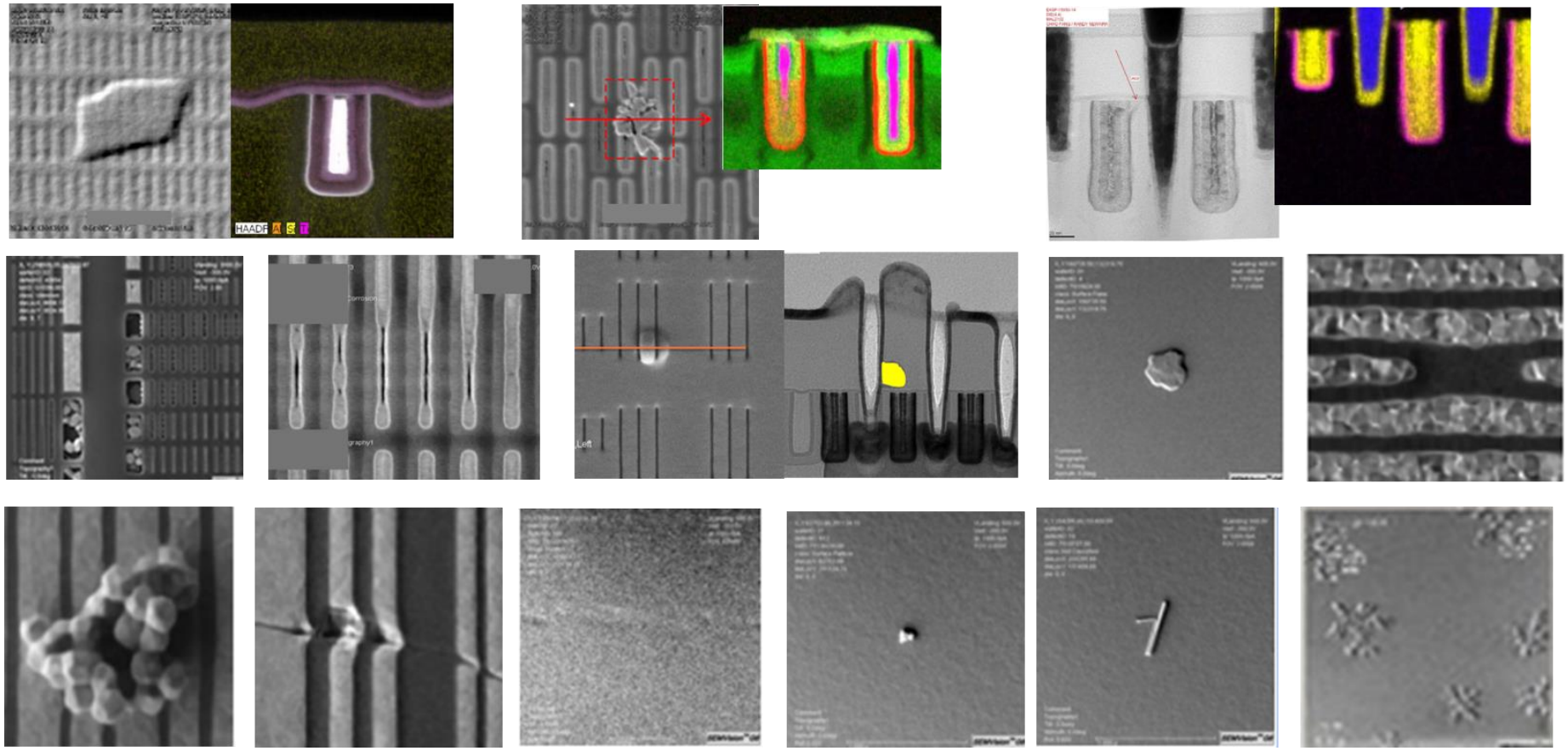
Defect and Post CMP Cleaning



Defect of Interest in this presentation:

- Metal Flake
- Particle
- Incomplete Etch
- Backside Ring

Approaches:

- Process Flow
- Cleaner Module
- Filtration
- Facility and Handling

Defect Scaling: micro to nano, nano to atomic scale defects are concerned

Defect and Post CMP Cleaning: what we know, what challenges are

We know traditional CMP defects: slurry particle, organic residue, metal fake, scratch

We know source of CMP defects: slurry, pad, disk, CMP cleaner

We know brush is critical to PCMP cleaning performance

We know brush cleans wafer and dirty wafer at the same time

Challenges:

“New” types defect – very thin metal flake/film defect

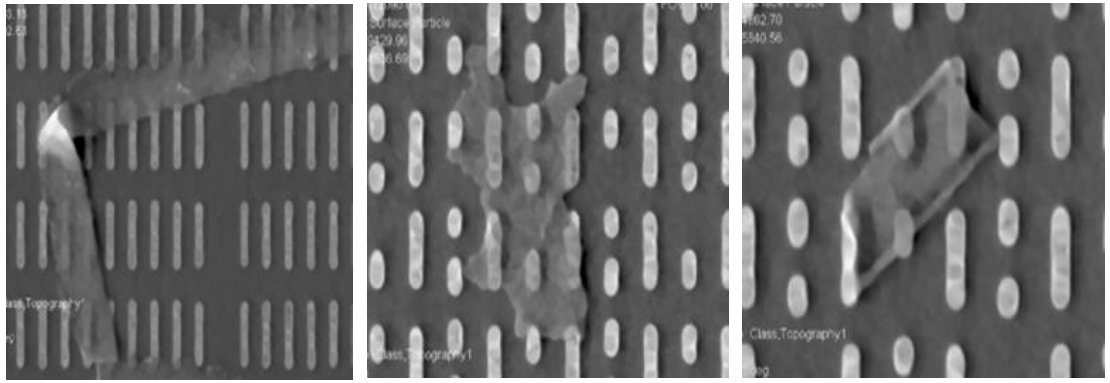
Small particle detection and removal

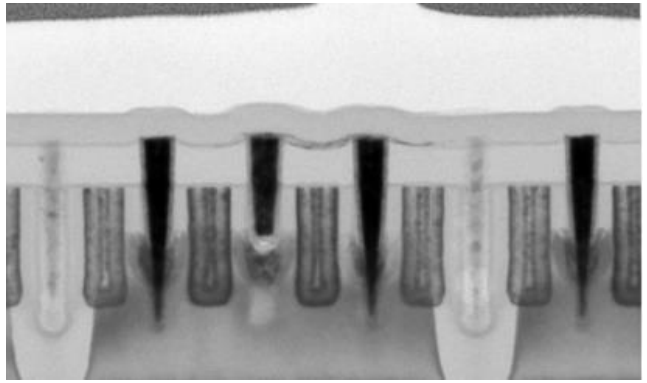
Integrated process induced defects – upstream, downstream, integration and their combination

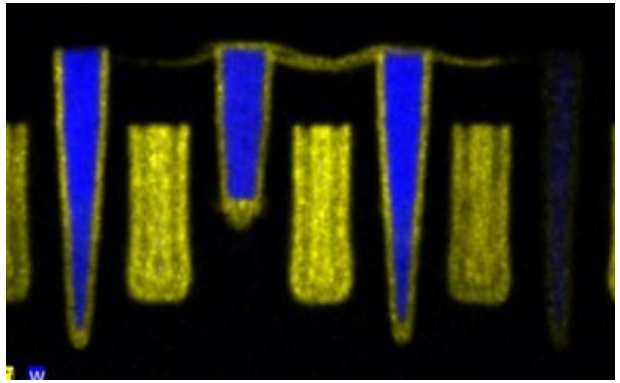
Process sensitive defects

Backside and edge induced defects

Thin Metallic Film I





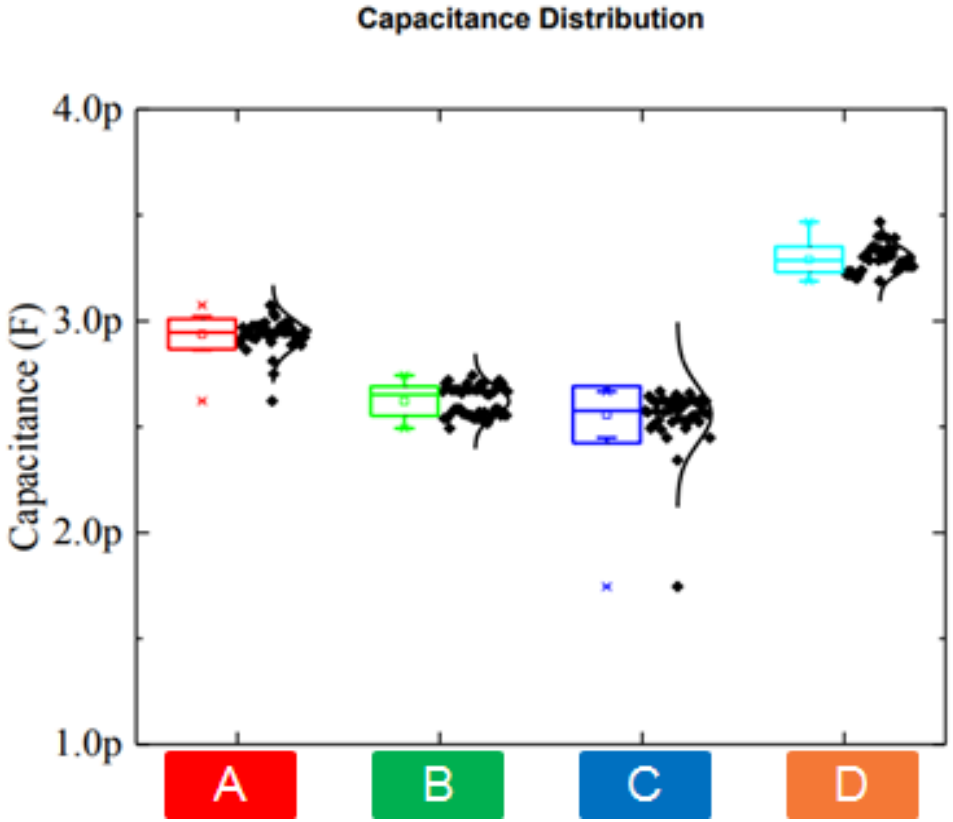


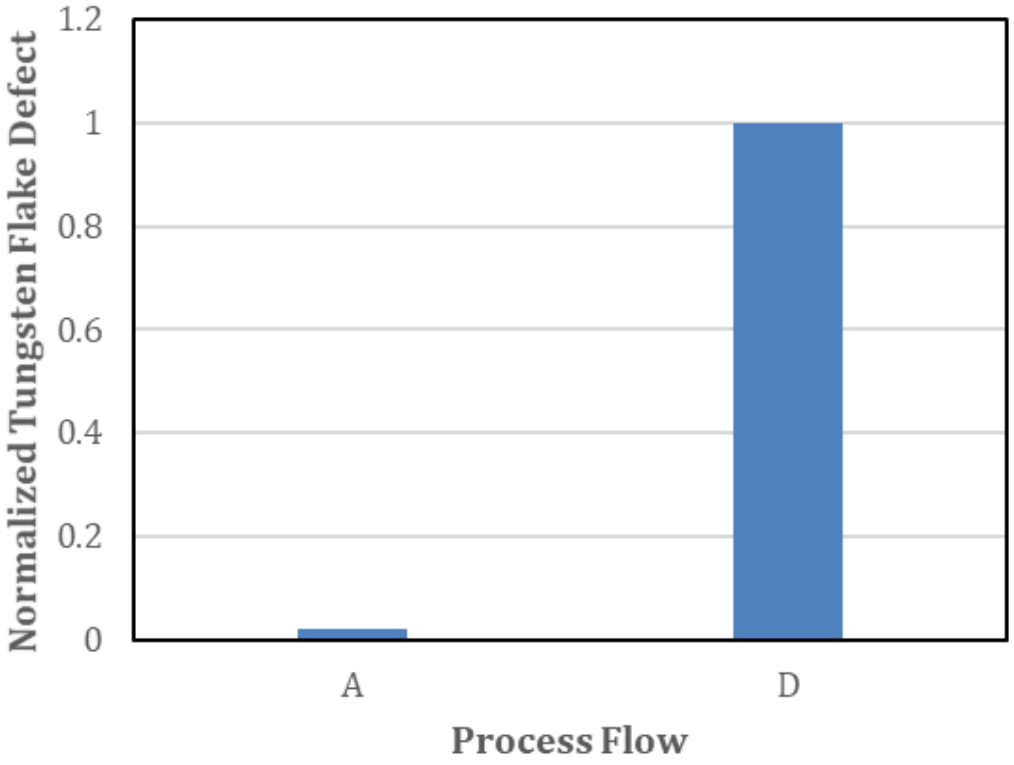
Thin Metal Flake

- Source of leakage path
- Very thin → Nanoflake
- Process integration related
- Detection is not easy (in particular, gate to contact)
- Surface charge is the mechanism to adhere to the surface
- Redeposit from brush during post CMP cleaning
- Brush breakin is critical to avoid metallic thin film defect

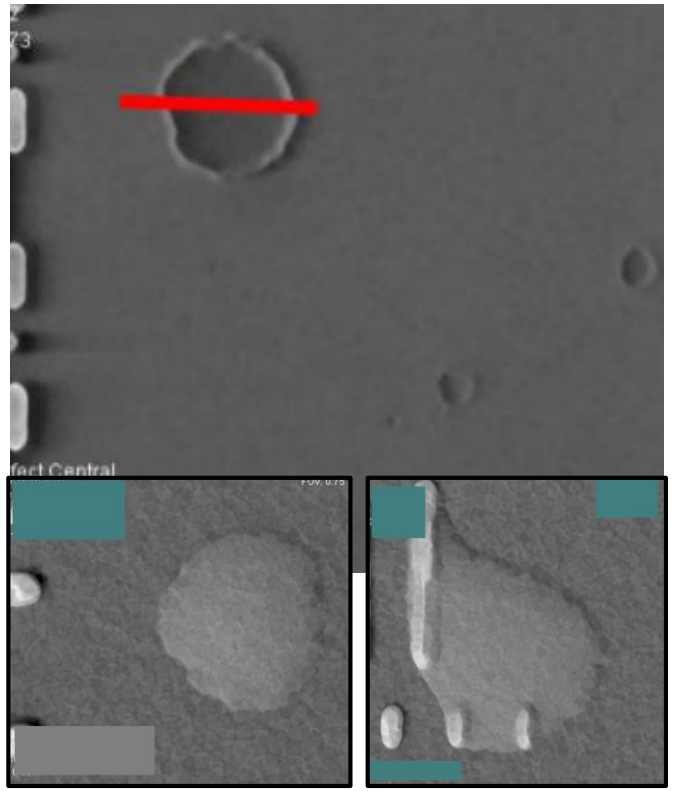
H J Kim, ECS JSST 7(4) P175-P179 (2018)

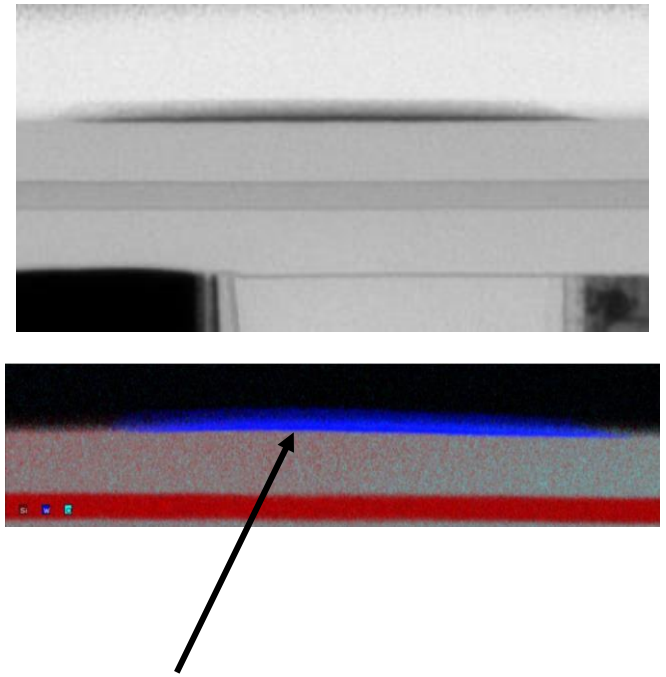
Thin Metallic Film – Integration Related





Thin Metallic Film II





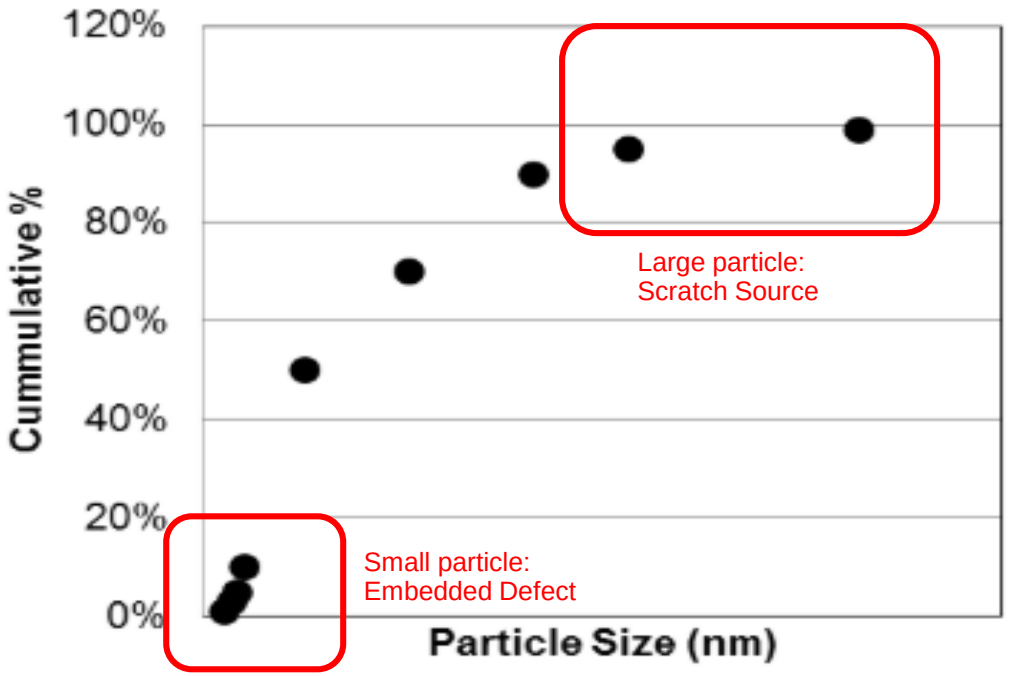
Metal dissolved during polishing/cleaning

Incomplete Drying

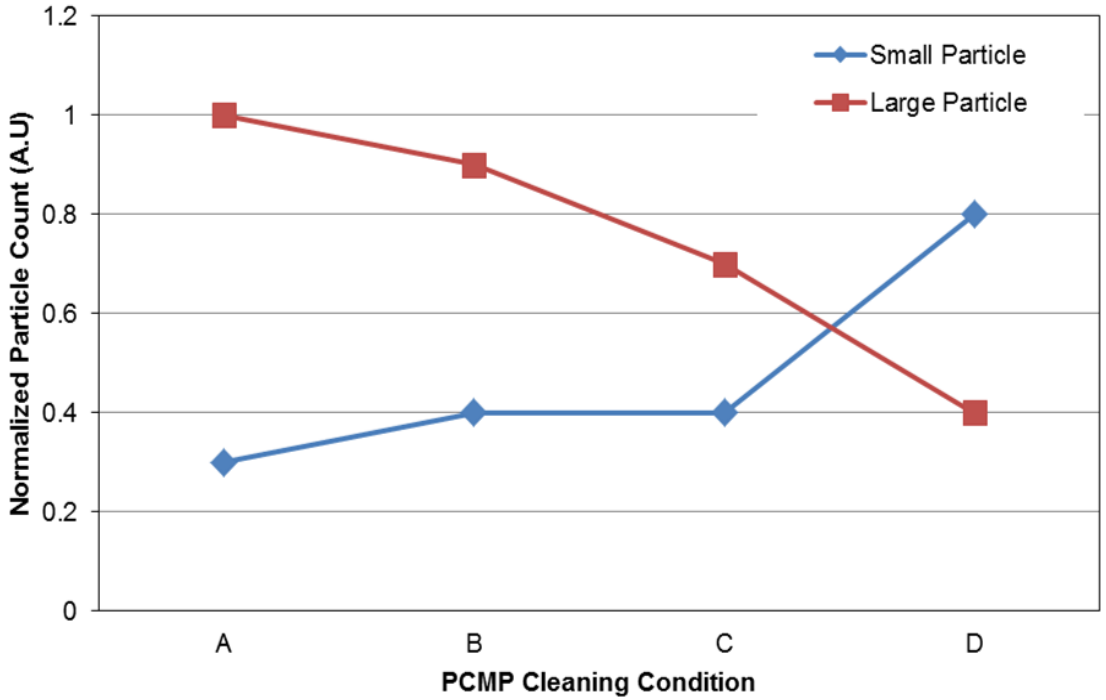
Dissolved Metal Precipitate & Water Mark

Particle Removal

Particle Size Distribution



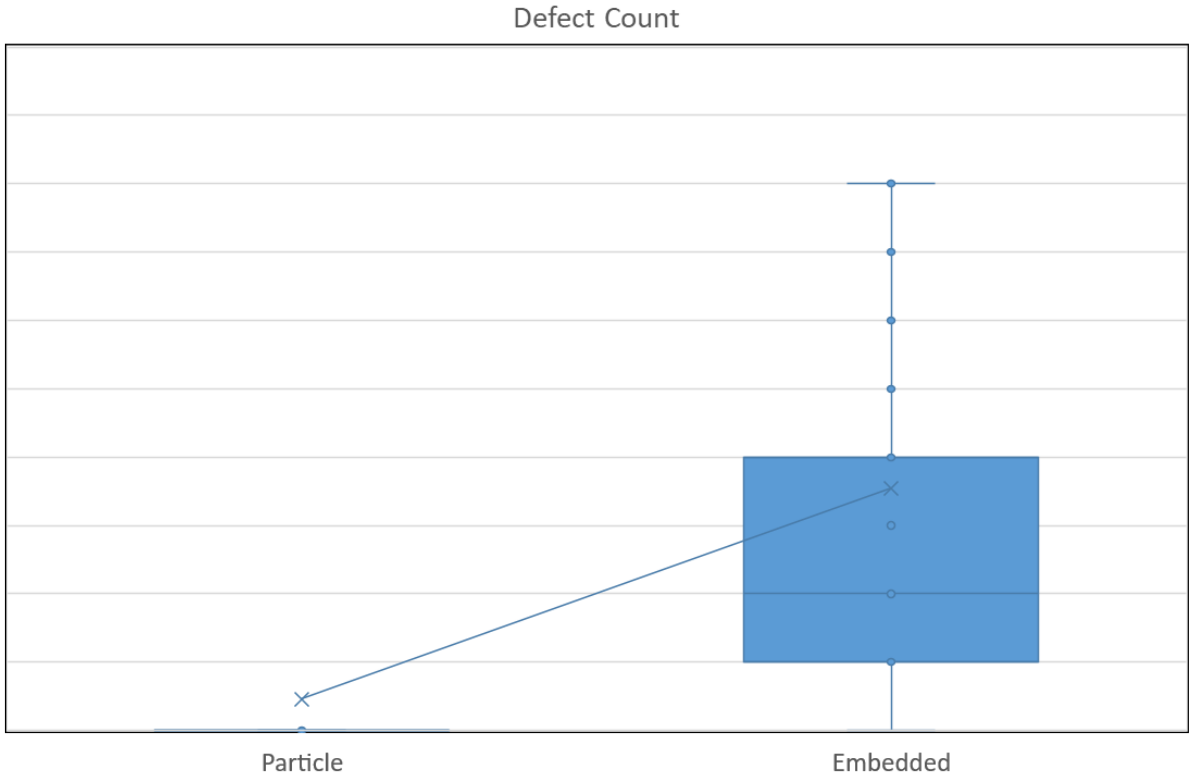
Particle Removal Behavior



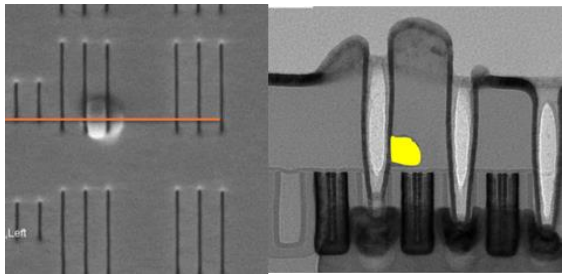
Both small particle and large particle are problem and critical to device performance

Small particle removal condition is different from large particle removal condition

Small Particle and Embedded Defect



- Embedded Defect: block etch → yield critical
- Detection Limitation: not detected right after processing → potential excursion
- Unable to Rework/Reprocess: scrap
- Difficult Source Investigation: multiple process steps involved
- SiO_2: same material as surrounding



Large and Small Particle Removal – Importance of Filtration

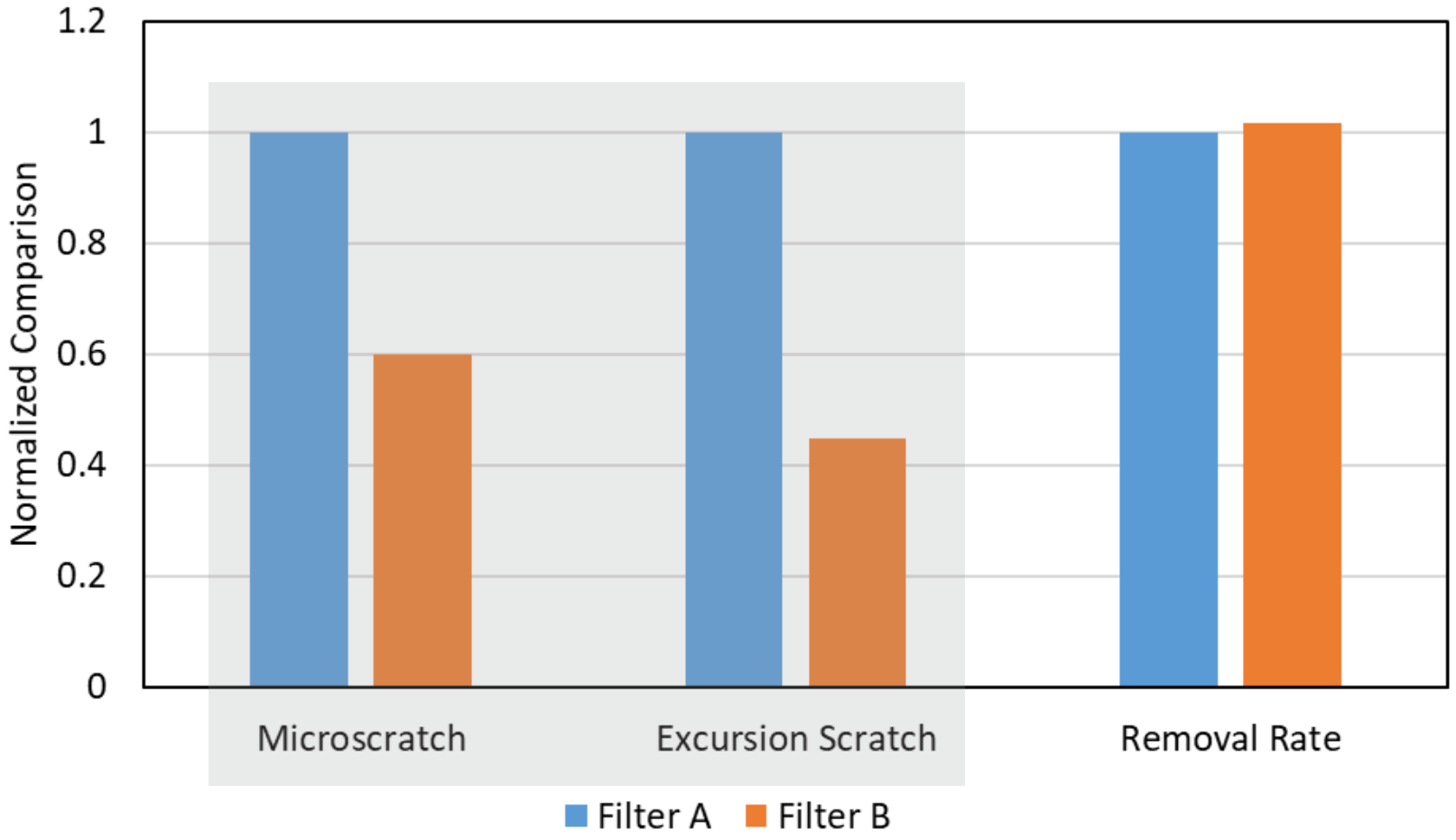
Example of filtration strategy:

Large Particle: Physical Trap → Smaller Pore Size Filter

Small Particle: Charge Trap → Surface Treatment

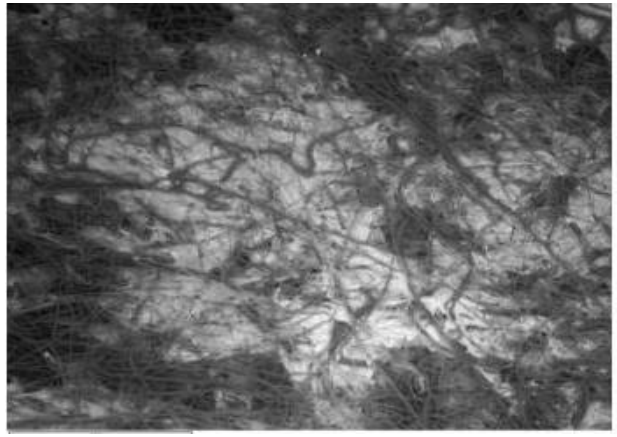
Chemical mechanical filtration?

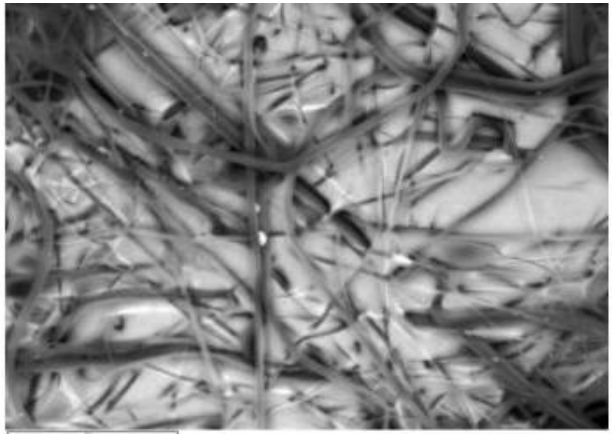
Effect of “Better” Filtration – additional benefit



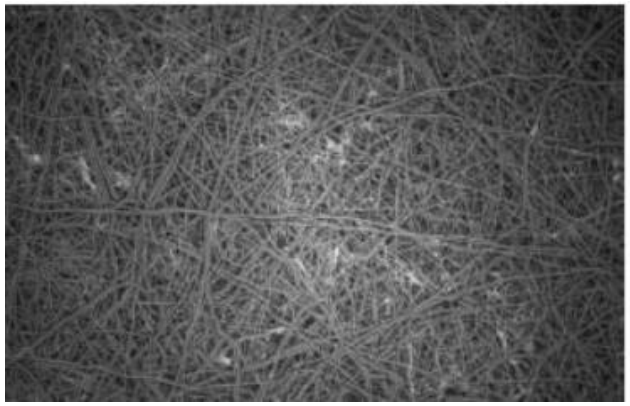
Effect of Filtration

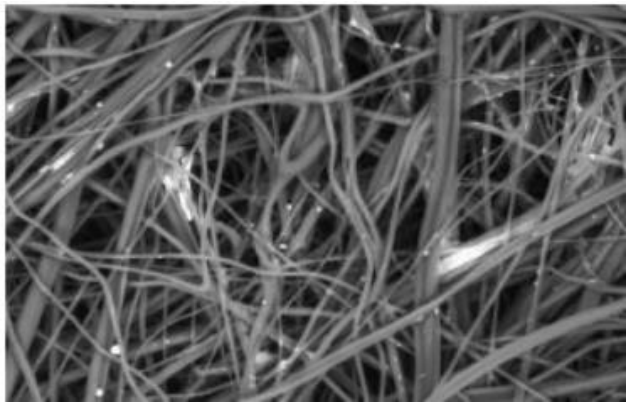
Condition A



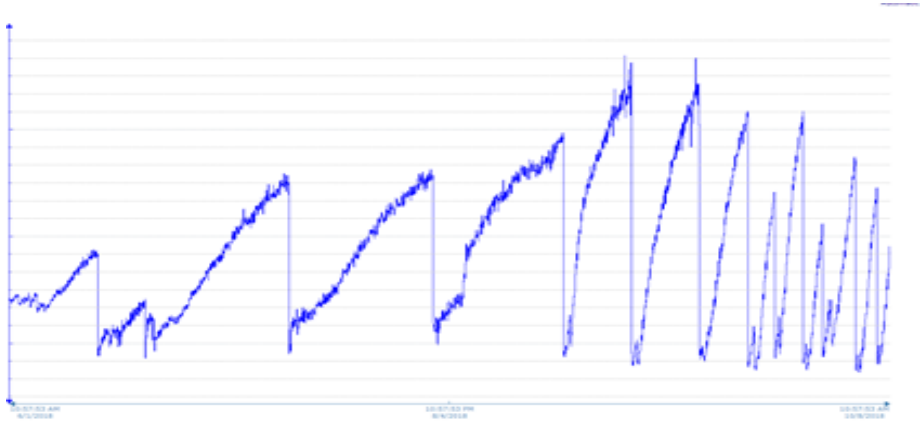


Condition B





Differential Pressure (DP) → DP is impacted by filter clogging, filter clogging becomes faster depending on environmental conditions → Potential defect source



Advances in Post CMP Cleaning

Requirements of PCMP cleaning

- High particle removal efficiency
- All size particle removal capability – “smaller” particle removal
- Minimize cross contamination
- Minimize substrate damage, ex) zero etch rate
- Brush breakin - pre or in-situ
- Backside cleaning efficiency
- Eco-friendly cleaning chemical

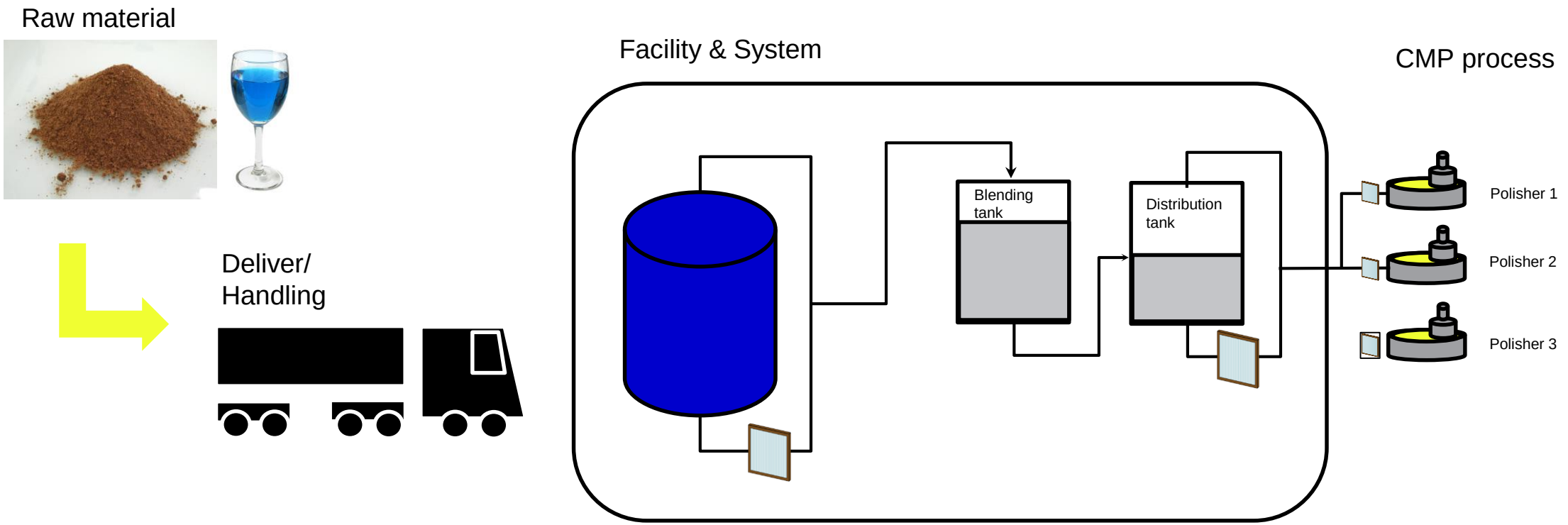
Recent development of PCMP cleaning

- Pre brush physical cleaning & in-situ brush breakin (SPCC2018)
- Ultrasonication brush breakin (ECS Journal 2019)
- Advanced clean chemistry (ICPT 2018)
- Advanced filtration (ICPT 2018)

Most development effort is focused on PCMP cleaning and cleaner module..

Holistic Approach To Defect Control

Raw material to wafer – where is the correct/proper area?

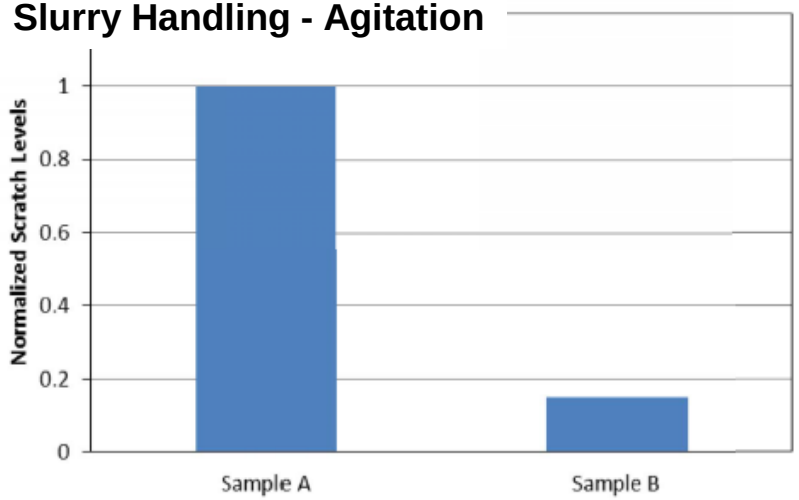


*) similar approach to polishing pad, conditioner, membrane…

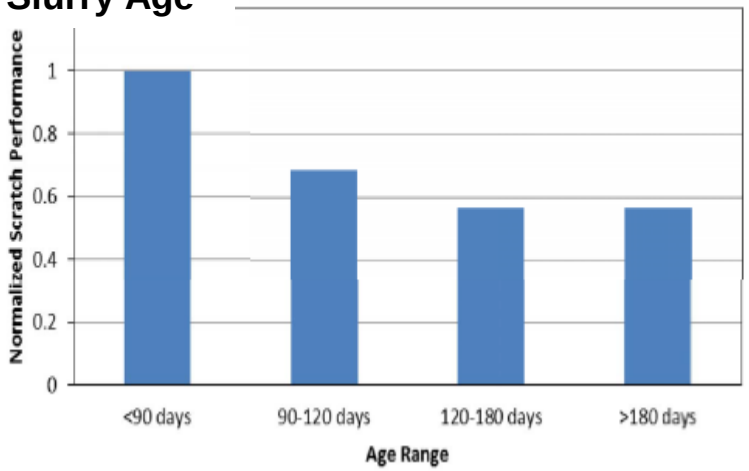
… prior to CMP Process

Examples for microscratch defect

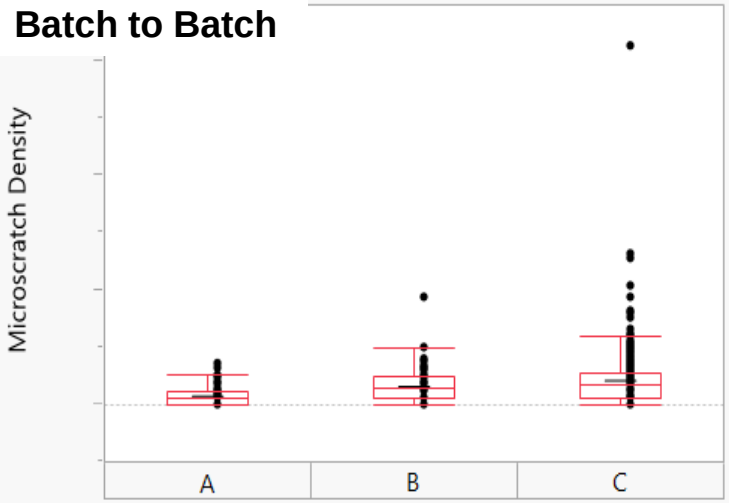
Slurry Handling - Agitation



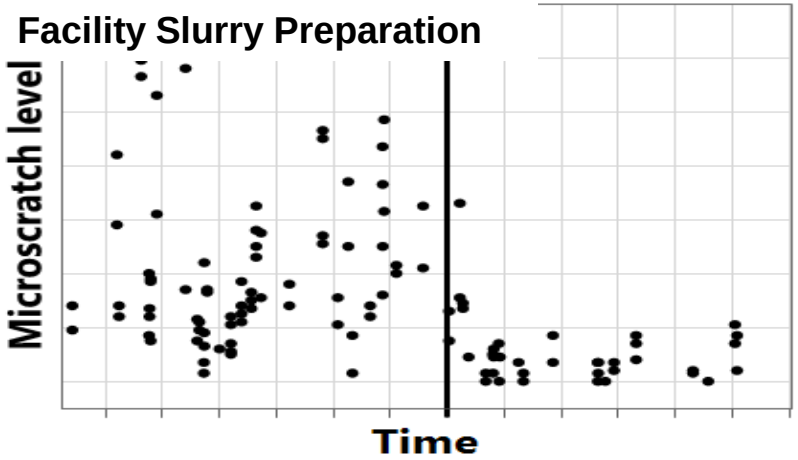
Slurry Age



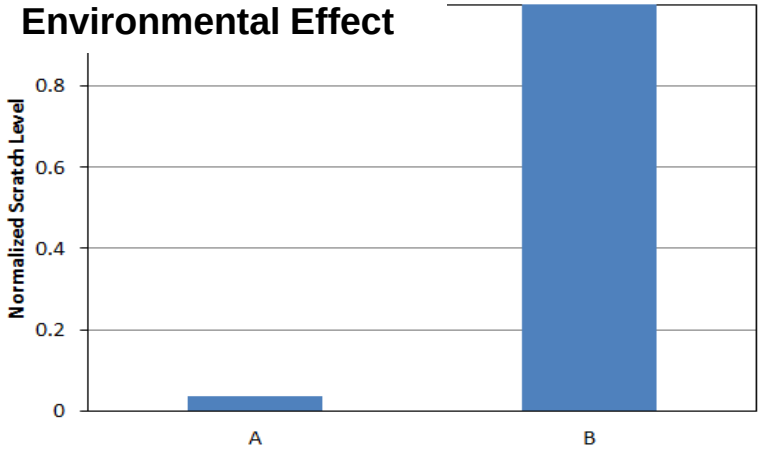
Batch to Batch



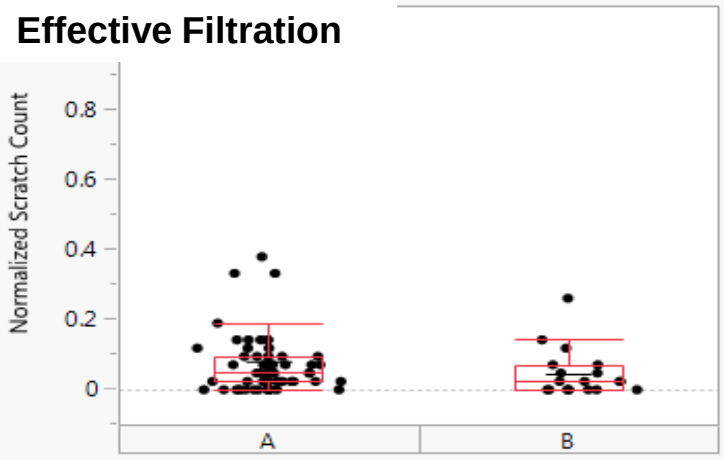
Facility Slurry Preparation



Environmental Effect

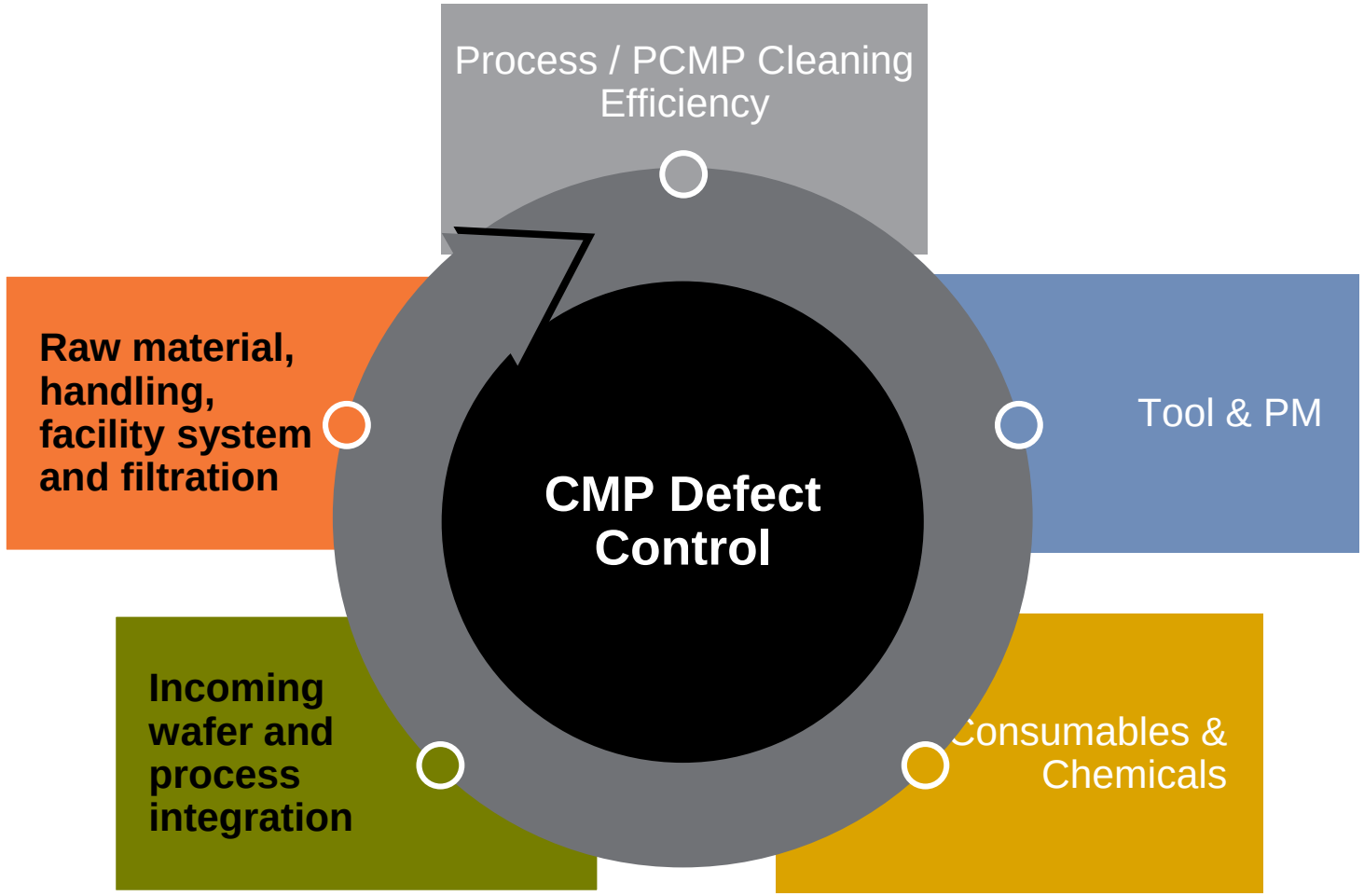


Effective Filtration



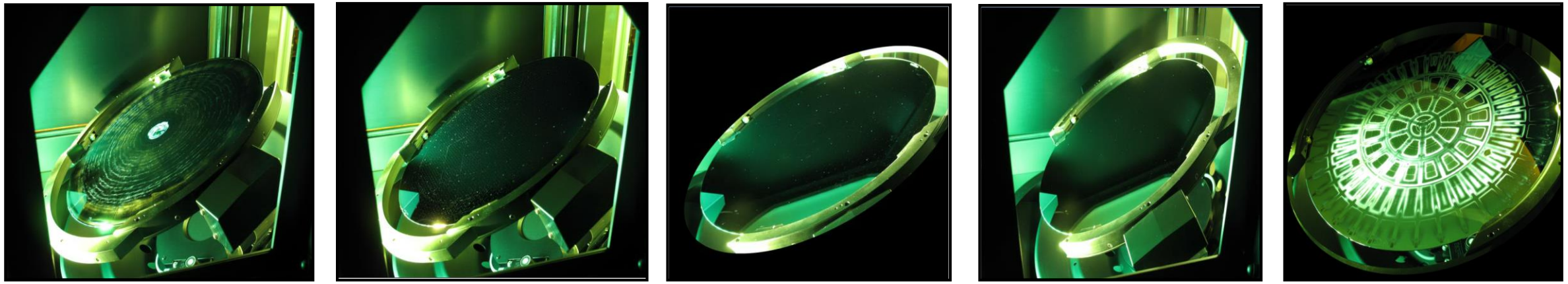
B Egan, ECS JSST 8(5) P3206-P3211 (2019)/ R Trivedi ICPT 2018

Defect Control Strategy

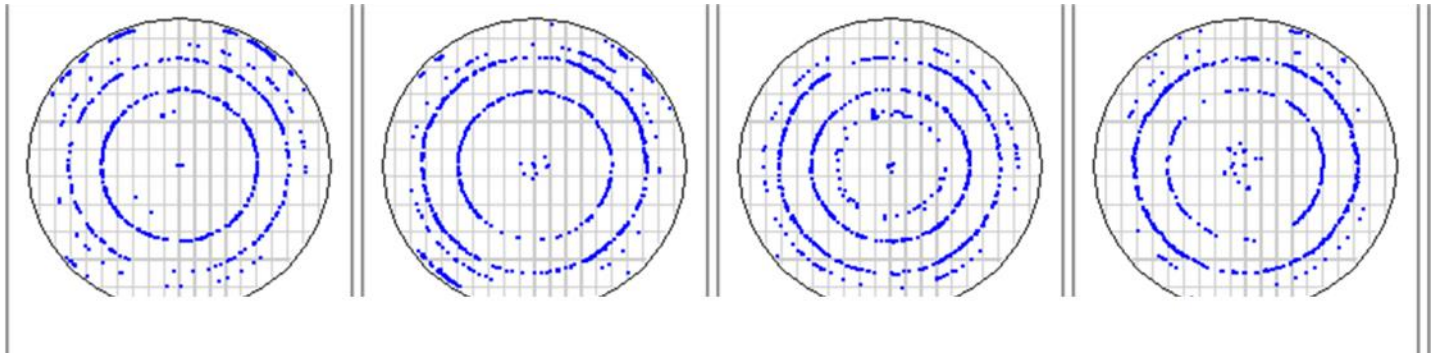


Wafer Backside Signature

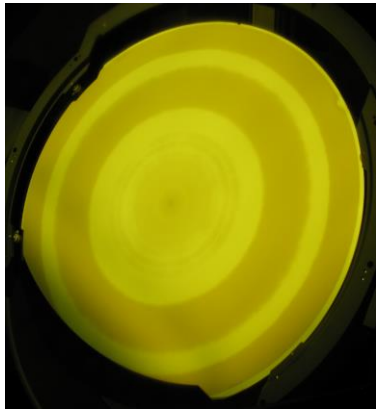
Examples of Backside Signature: Chuck mark from deposit, thermal processing, clean… tools



Backside Defect Map

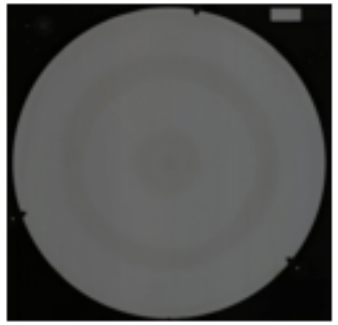


Ring Signature



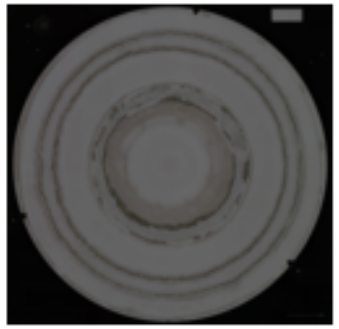
Effect of CMP on Wafer Backside Ring Signature

- Location → Inner ring, outer ring
- Pattern → Match with CMP clean nozzle location
- CMP and combined downstream process make backside ring signature

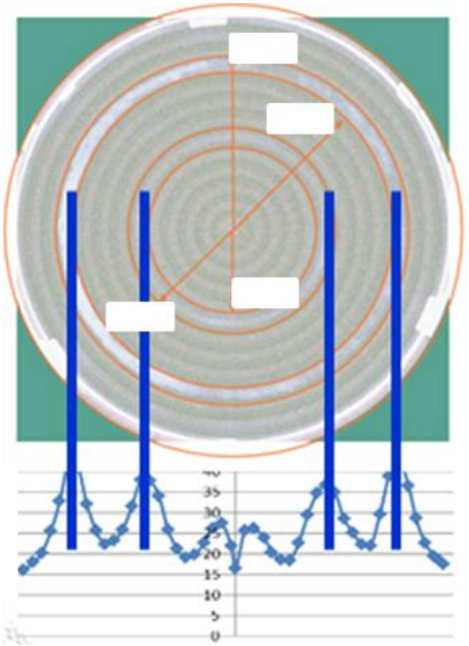


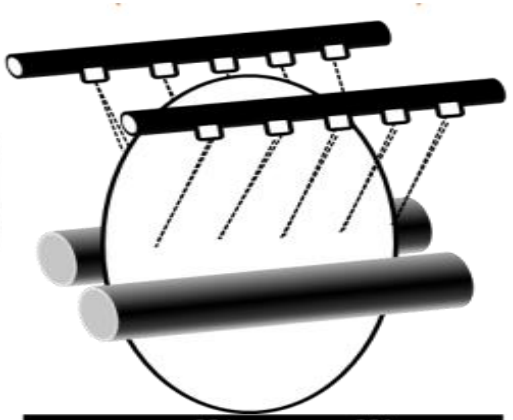
CMP processed

CMP2, CMP3,…

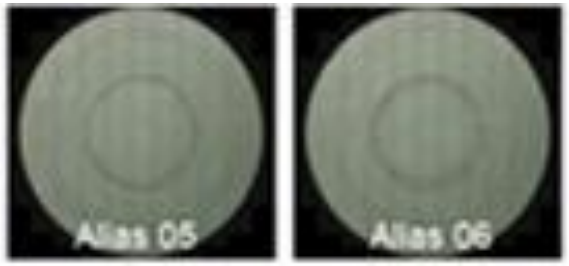


Downstream effect

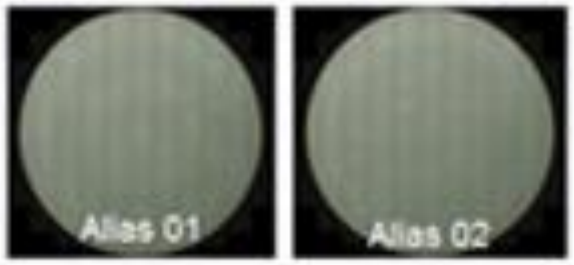




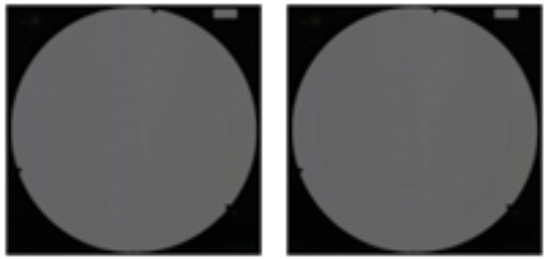
	BB1	BB2
FEOL	HF	SC-1
MOL	HF	NH4OH



Process Condition A



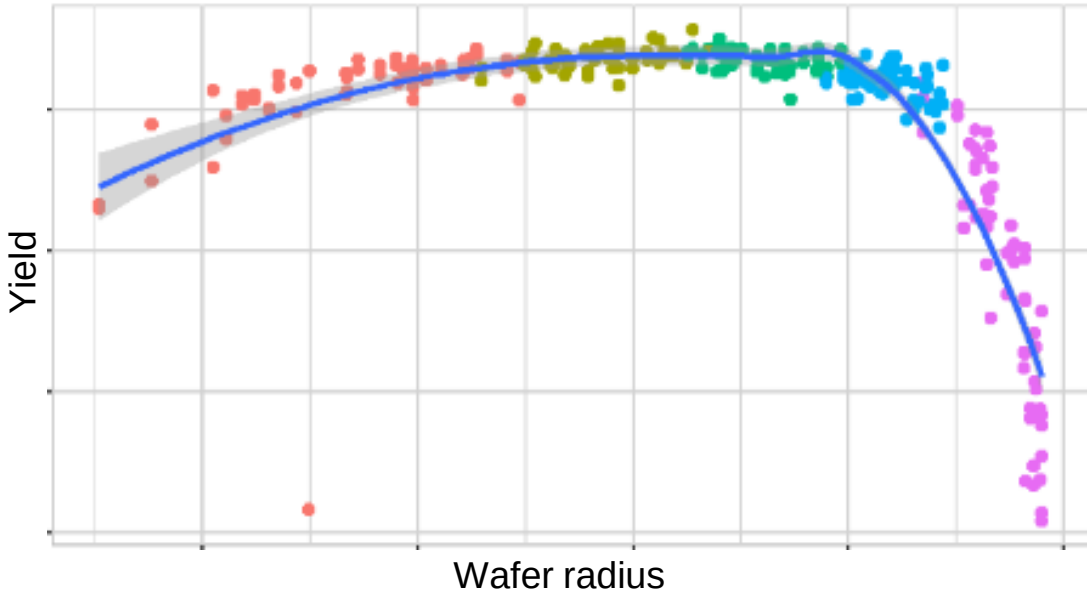
Process Condition B



Process Condition C

Effect of Wafer Edge

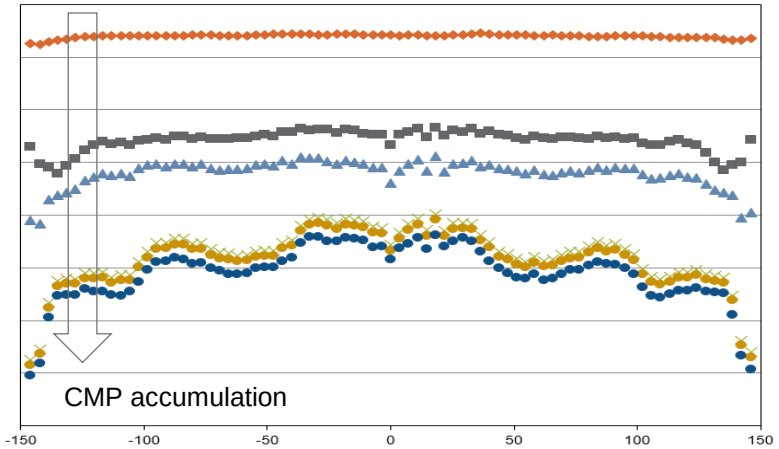
Yield Distribution: center to edge

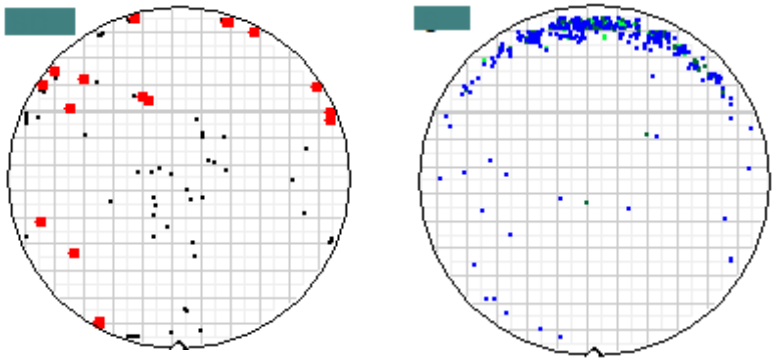


Edge uniformity

CMP Perspective

Edge defect





Summary and Conclusion

Holistic Approach

- **Integration is critical to defect generation**
- **Defect control from raw material quality, handling, environment to process**
- **Wafer edge and backside cleanliness**
- **New design for PCMP cleaning module – CMP is cleaning technology**

Thank you

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