Effect of Incoming Quality of Sulfuric Acid on Inline Defects

Dhiman Bhattacharyya*, Sushil Patil, Mark Conrad, Hayley Manning, Fauzia Khatkhatay, Alexander Mena and Norberto DeOliveira

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Dhiman Bhattacharyya, Ph.D.
GLOBALFOUNDRIES
400 Stonebreak Rd. Ext., Malta, NY - 12020
Mobile: 518-415-2311
Email: dhiman.bhattacharyya@globalfoundries.com

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Outline

- Background
- Problem Statement
- Root cause investigation and results
- Summary

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Background

- Hydrogen peroxide and sulfuric acid are the major consumables in Cleans.
- They are used in mixture in conventional cleans as Sulfuric and Peroxide Mixture (SPM or Piranha) which is then followed by Ammonia Peroxide Mixture (APM or SC1 or RCA1).
- Wet cleans using SPM is predominant in FEOL.
- High volume device manufacturers need to have multiple sources of materials for continuous supply chain.
- Any particle excursion in any chemical can potentially degrade the inline defects.

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Background

Tech node

Avg Wet Cleans Steps

Defect Inspection

Technology node

- Technology is shrinking,
- Wet cleans contribution to keep the wafers clean is significantly increasing,
- Sensitivity of Dark Field detection is increasing.

Background

Detection Limitation:

- Difficult to detect any excursion in incoming particles if the particles are smaller than the detection limit.
- Current state of the art detection limit is 45nm by liquid particle counter.
- Inline defect detection can also miss the defects on the wafer in similar situations where defects are smaller than the detection limit.

Variability in sulfuric acid manufacturing:

- Sulfuric acid is usually produced using either glass or Teflon-lined steel absorption tower in high volume manufacturing environment.
- Glass lined column may introduce silica like particles.
- Teflon lined column may introduce carbon particles.

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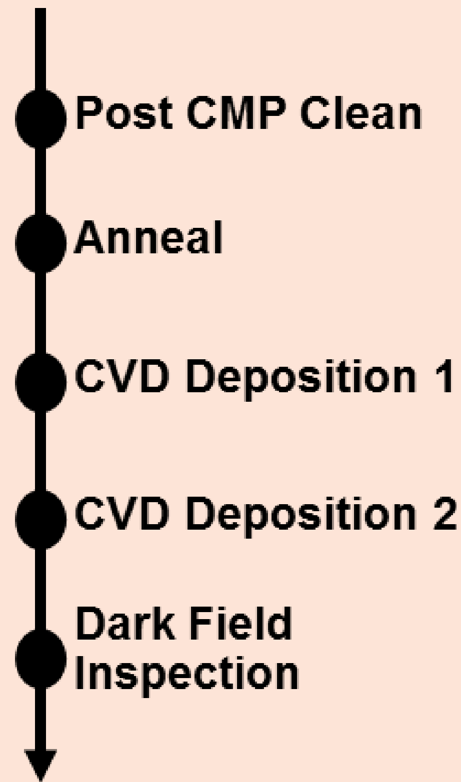
Problem Statement:

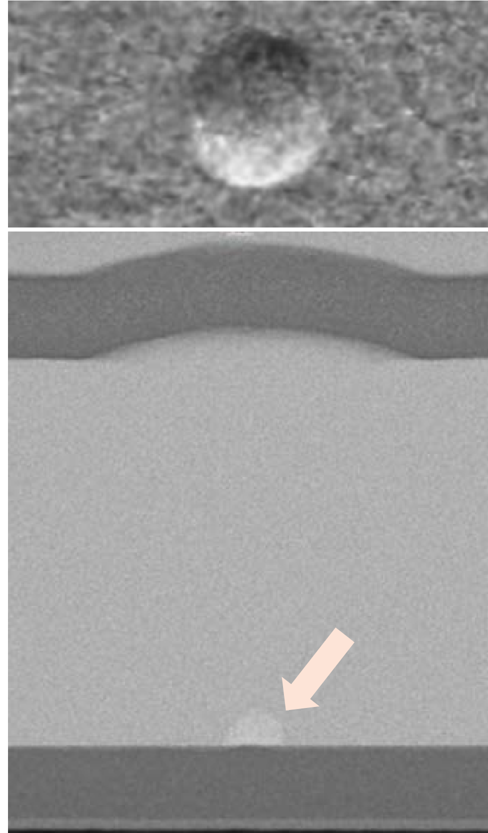
Relative TDC

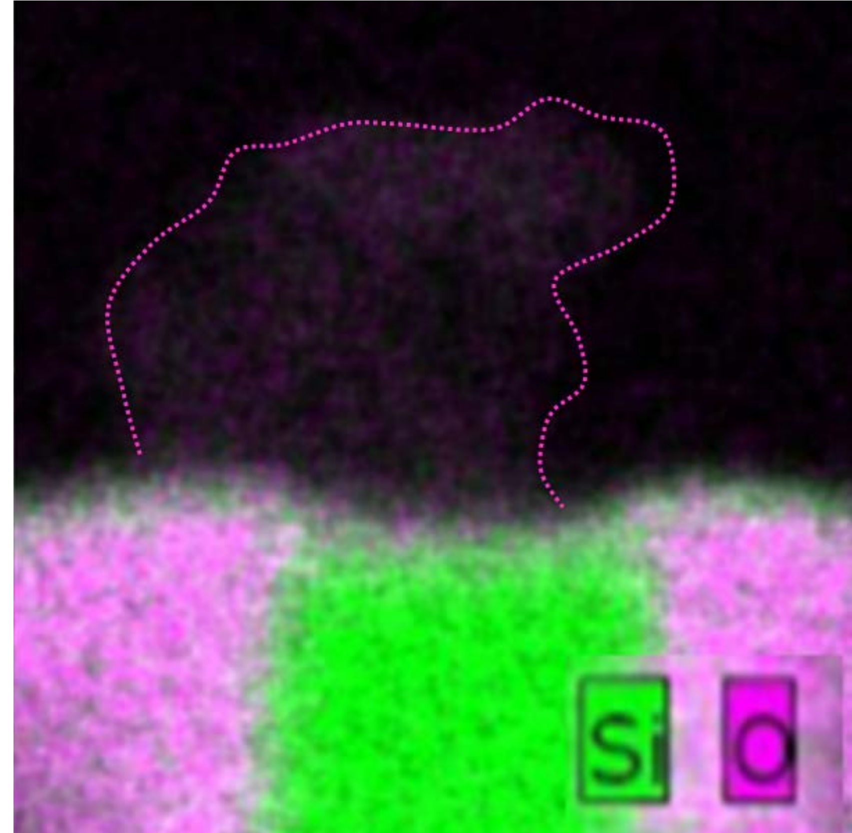
Time/days

- The relative TDC (total defect counts) at a DF inspection step continuously improved over the time.
- Baseline defectivity significantly reduced.
- However, the TDCs jumped back to old baseline all of a sudden with no apparent correlation to any process or equipment or environmental changes.

Problem Statement:







- This DF inspection detects any excursion in Post CMP Clean as embedded defects.
- Even particles as small as ~10nm are visible as embedded after being decorated by 2 CVD films.
- DA clearly showed that the particles were composed of Si & O.

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Root cause investigation and results

Approaches to identify the root cause of these defects;

(1) Failure analysis of the particles,

(2) Comparison of defects from various components of the production recipe to conclude the defect source,

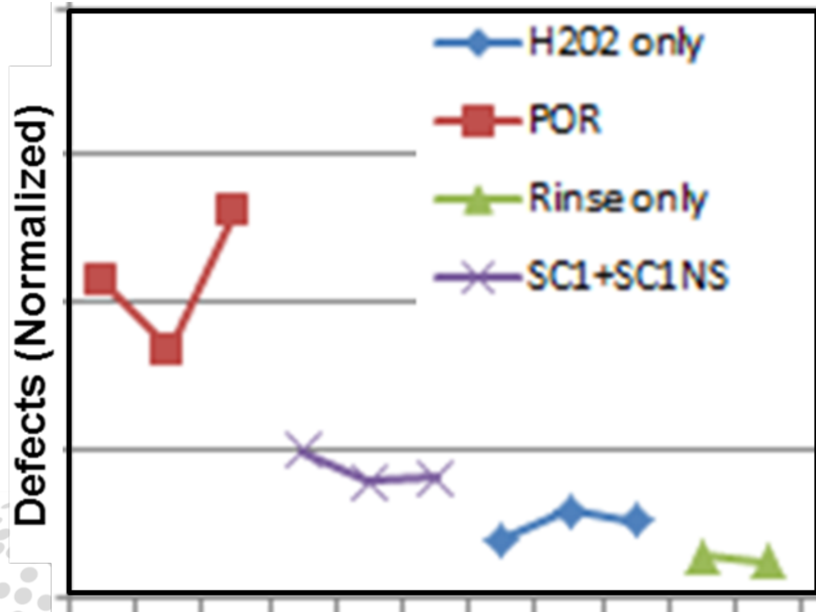
(3) Comparison of defects from cleans process recipes with different SPM dispense times, and

(4) Analysis of the defect trend versus the supply chain in real-time.

Root cause investigation and results

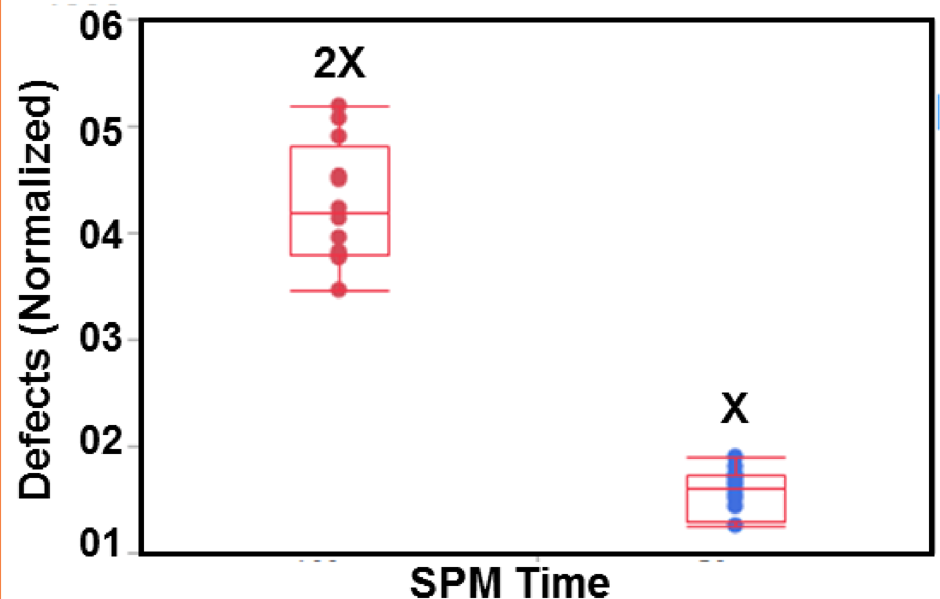
Comparison of defects from various components of the production recipe:

- The recipe was broken down into each chemistry.
- POR recipe, only which had SPM in it showed highest defect counts.

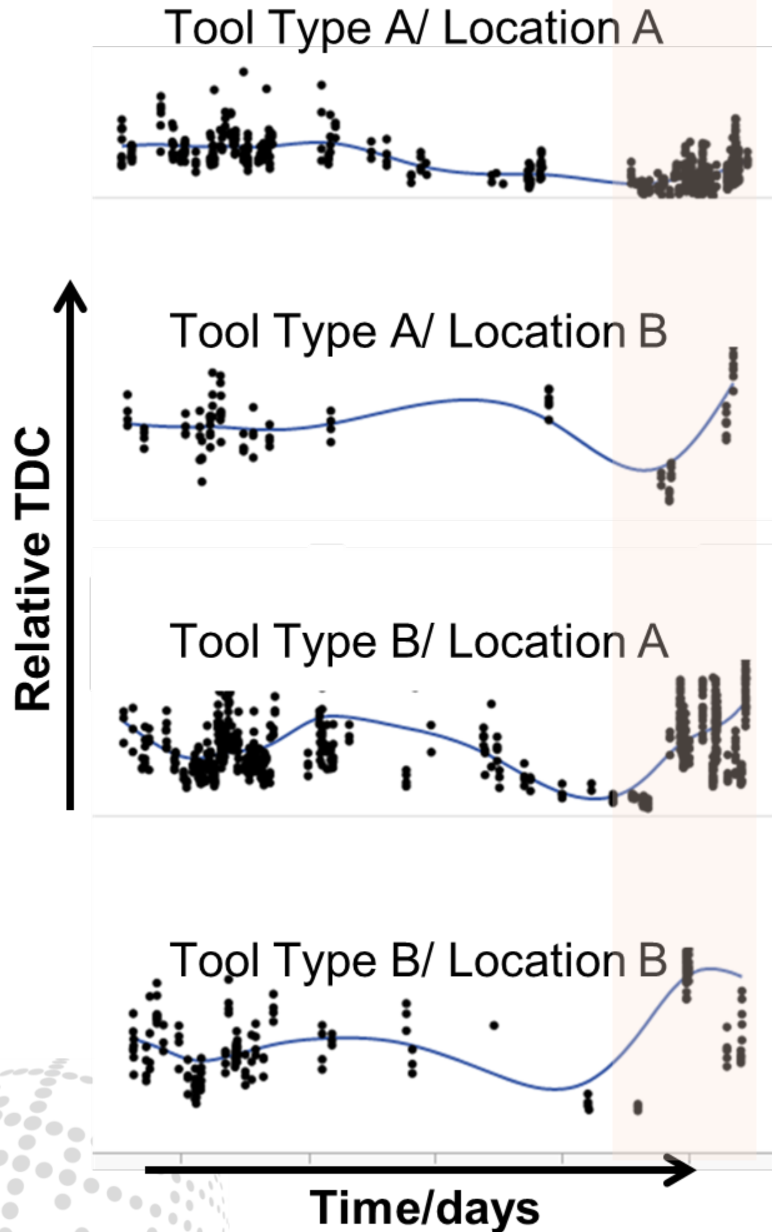


Comparison of defects from cleans process recipes with different SPM dispense times:

- An experiment with 50% reduced SPM dispense time at the same operation was performed.
- It helped in >75% reduction of the defects



Root cause investigation and results



- Initial investigation was limited to very specific tools located to a specific location.
- The sensitivity of such tools in such location was in doubt.
- As time progressed, a clear uptrend in TDCs was noticed in all kinds of tools independent of where they were located.

Root cause investigation and results

Defects (Normalized)
03
02
01
Time (Hours)

0H
12H
24H
Time (Hours)

- A real-time experiment was carried out where the sulfuric acid manufactured in glass-lined steel absorption tower was stopped at the chemical feeder pump while the other source was continued to supply the operations.
- One experimental lot (12 wafers) was split in to three and each of the three sub-lots was processed at the post-CMP operation at a 12 hour interval.
- A very clear downtrend of defects in real-time was observed when the supply was flushing the silica contaminated material out.

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Root cause investigation and results

S1   S1 + S2

Defects (Normalized)

30
25
20
15
10
05
01

Time (Days)

- Sulfuric acid has been used in bulk from both the suppliers (S1 and S2).
- The defect baseline came down when supply from S2 was interrupted for few months.
- Baseline trended up again when supply from S2 was restored.
- Defect level trended down after supply from S2 was stopped.
- S2 was found to have glass lined column while S1 had Teflon lined column.

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- Evaluation of the supply
- **Summary**

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Summary

- Difficult to detect any excursion in incoming particles if the particles are smaller than the detection limit. Current state of the art detection limit is 45nm by liquid particle counter.

- Inline defect detection can also miss the defects on the wafer in similar situations where defects are smaller than the detection limit.

- Any particle excursion in any chemical can potentially degrade the inline defects.

- Sulfuric acid is usually produced using either glass or Teflon-lined steel absorption tower in high volume manufacturing environment.

- The difference in manufacturing process introduces variation in the type of defects both in quality and quantity.

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Acknowledgment:

- *All colleagues in GLOBALFOUNDRIES*

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Thank You

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