



**DNP**

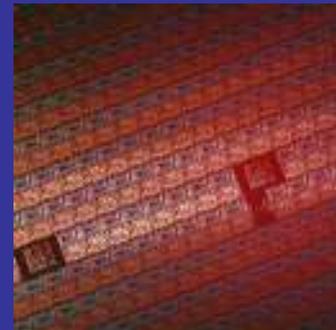
Accelerating the next technology revolution

# Cleaning performance evaluation of EUV mask blanks using Lasertec M7360

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# Outline



- Introduction: Cleaning challenge
- Cleaning performance evaluation
  - Particle removal efficiency (PRE)
  - Adders
- Reduction of Adders
  - Adders characterization
  - Megasonic condition optimization
- Summary

# Introduction



- Readiness of defect-free EUV mask still remains a critical challenge
- EUV mask defect requirements (2010 ITRS)

Year of Production	2010	2011	2012	2013
Flash HP (nm)	32	28	25	23
Defect size (nm)	36	32	29	25

- Cleaning process must be capable of cleaning 25 nm soft defects for the 23 nm HP NAND Flash
- Best sensitivity with an applicable inspection tool is ~43 nm (SiO<sub>2</sub> standard particle) on Ru-capped EUV mask blanks

This presentation addresses the cleaning performance for ~ 43 nm defects on EUV mask blanks

# Experiments



- Cleaning tool
  - Hamatech mask track
- Inspection
  - Lasertec M1350 (71 nm SiO<sub>2</sub> particle sensitivity)
  - Lasertec M7360 (43 nm SiO<sub>2</sub> particle sensitivity)
- Blanks
  - Ru-capped EUV mask blanks

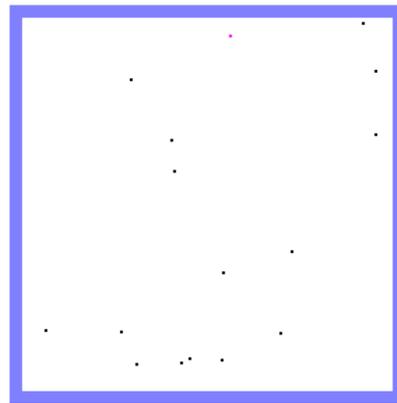
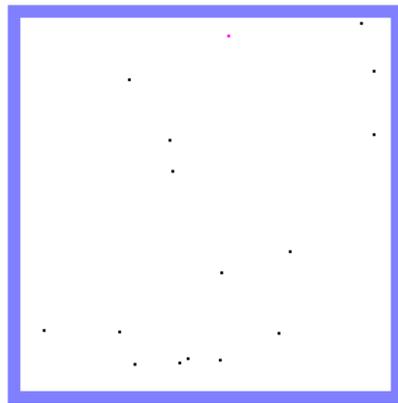
# PRE evaluation



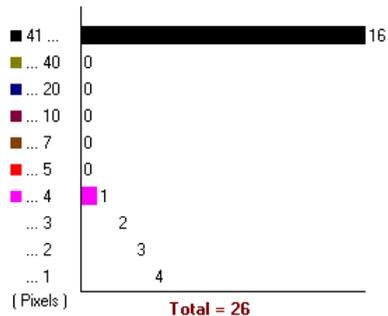
## M1350 (>71 nm)

Contaminated defects

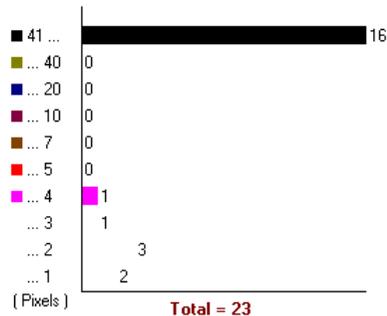
Removed defects



Pixel Histogram



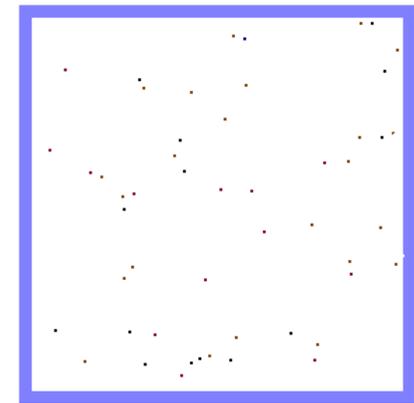
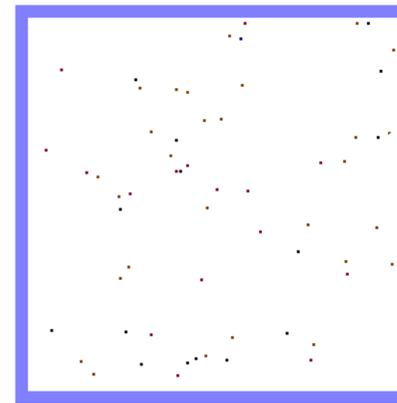
Pixel Histogram



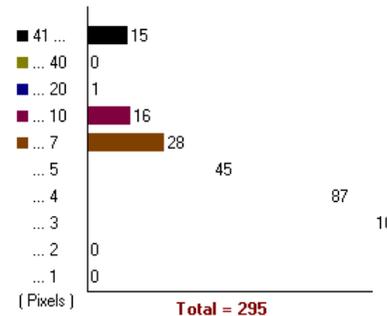
## M7360 (>43 nm)

Contaminated defects

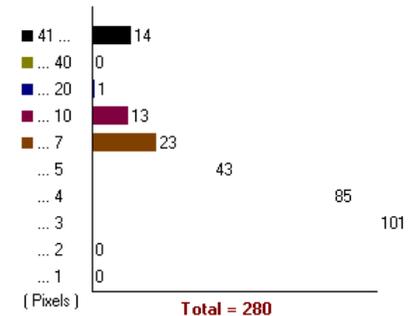
Removed defects



Pixel Histogram



Pixel Histogram



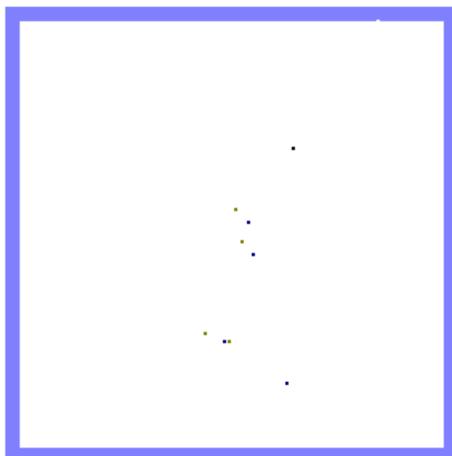
**PRE (>71 nm) = 17/17 x 100 = 100%**

**PRE (>43 nm) = 50/59 x 100 = 85%**

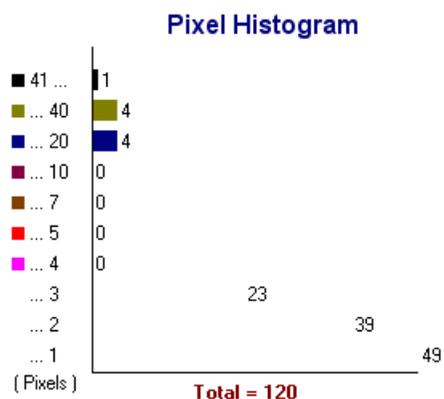
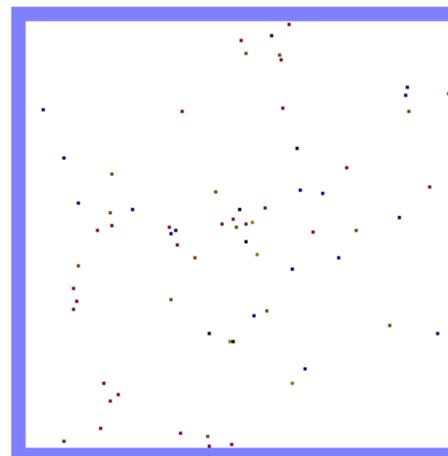
# Added defects evaluation



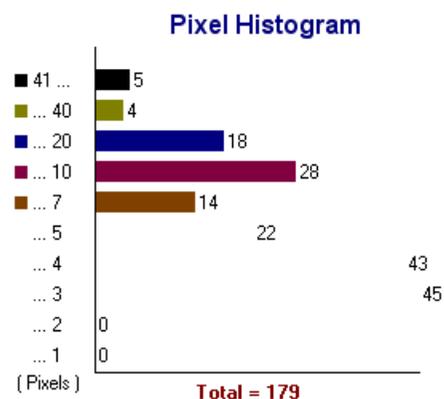
**M1350 (>71 nm)**



**M7360 (>43 nm)**



**9 adders**  
**>71 nm (+4 pixels)**

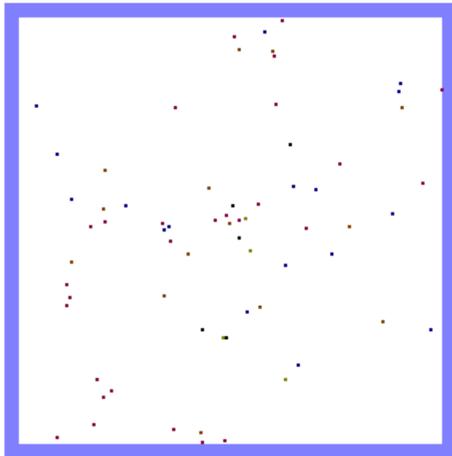


**69 adders**  
**>43 nm (+6 pixels)**

# Adders characterization

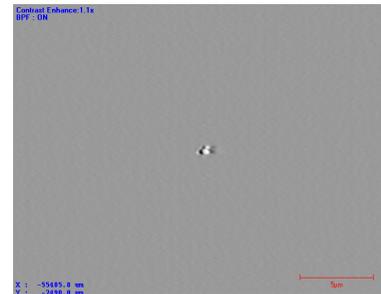


Added defects map

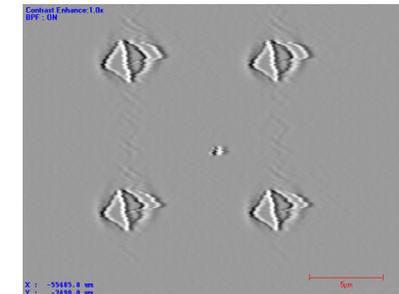


Chose 35 of 69 adders

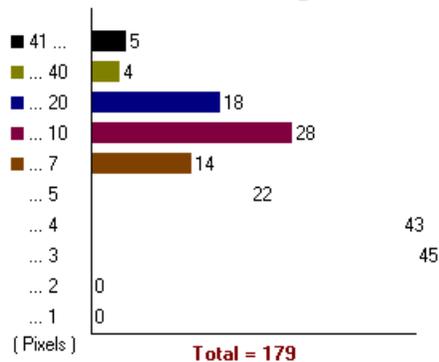
Review image



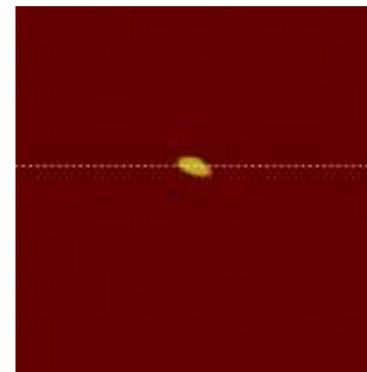
Marking



Pixel Histogram

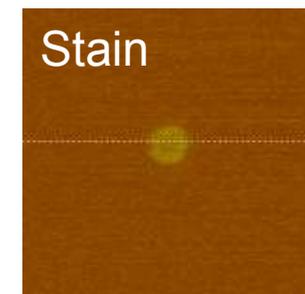
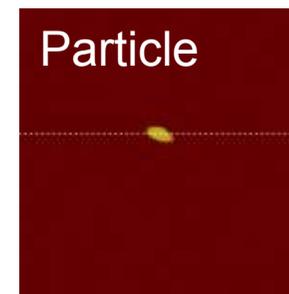
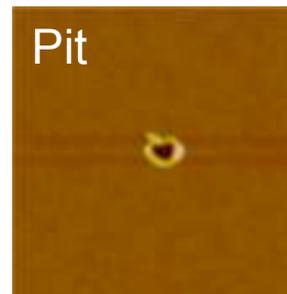
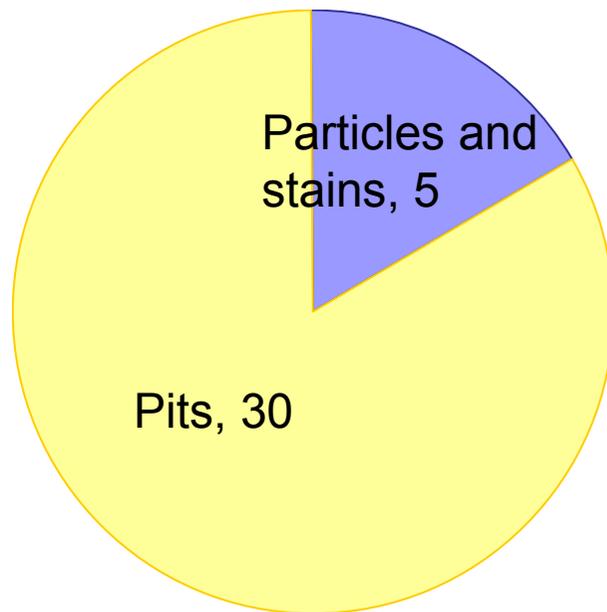


AFM



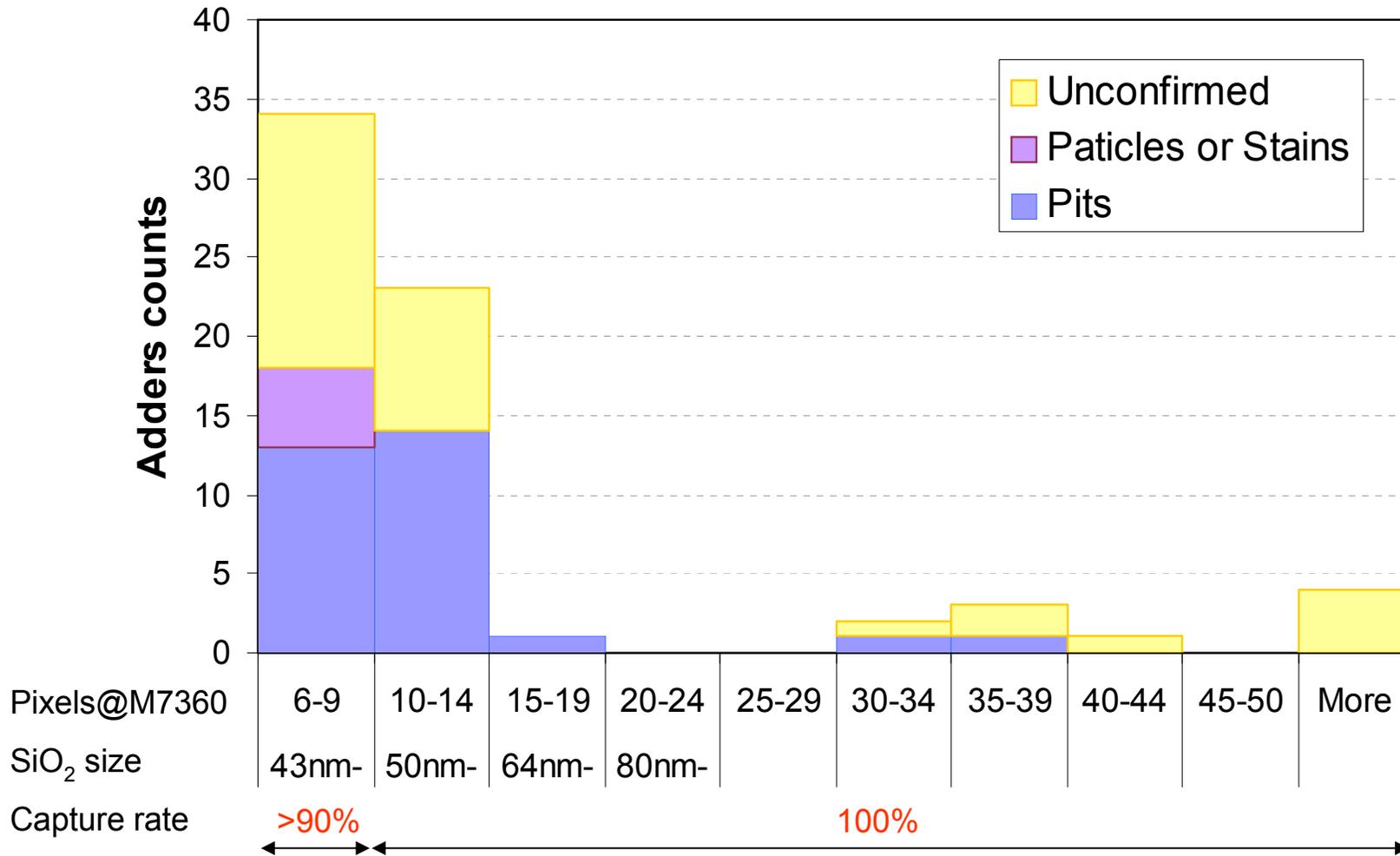
# Pareto chart of adders

35 of 69 adders



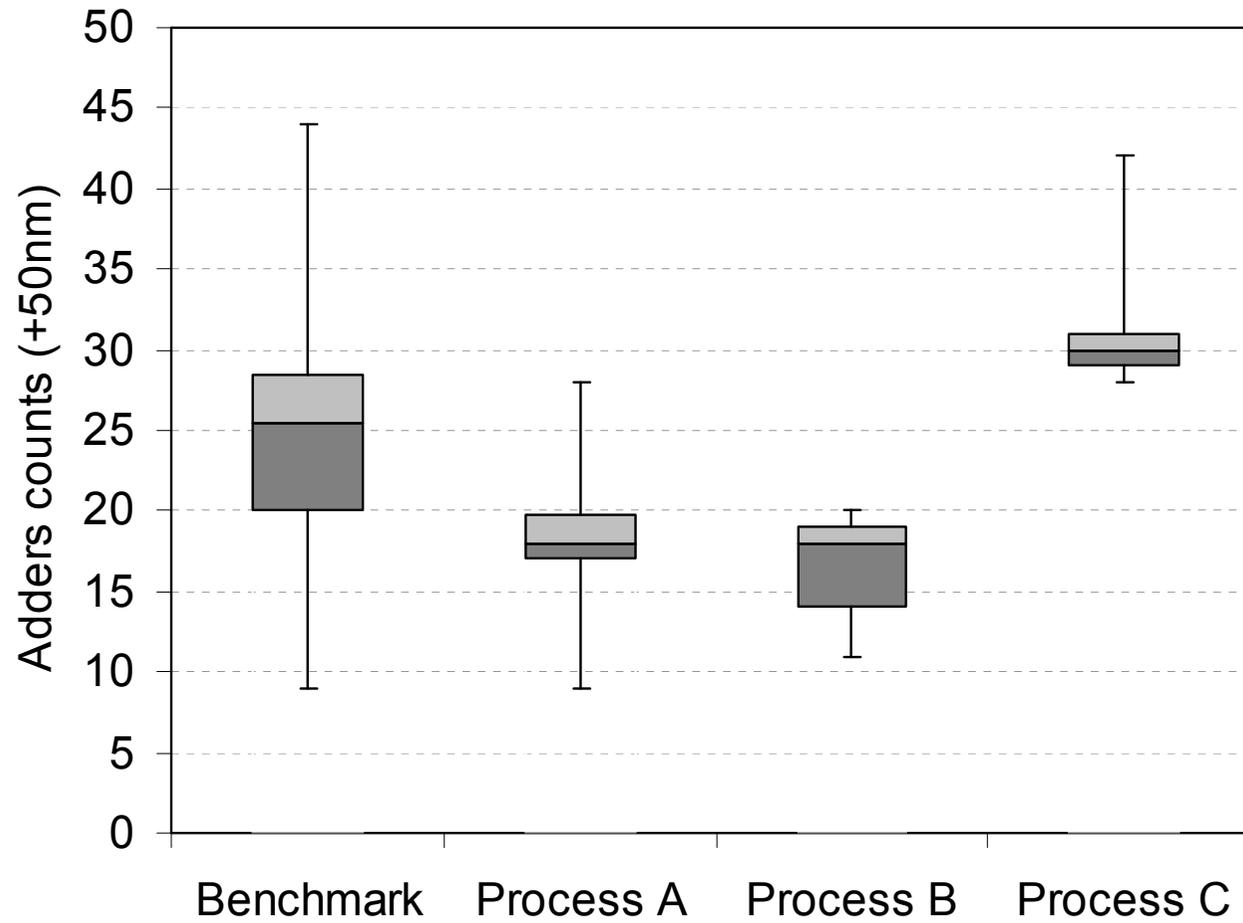
- ✓ Majority of adders are pits
- ✓ Megasonic is likely root cause of the pits

# Classification by size



Focused on +pixel 10 (+50 nm) to mitigate pit adders

# Adder mitigation



Lower megasonic power and higher frequency

# Summary



- Evaluated cleaning performance using Lasetec M7360 with 43 nm sensitivity on Ru-capped EUV mask blanks
  - PRE has been at acceptable level, although needs further improvement for small particles
  - Identified reducing pit adders as the key challenge for EUV mask blanks cleaning
- Optimized cleaning process, particularly megasonic condition
  - Achieved 30% improvement in pit adders