EUV Defects – Kevin Cummings

ASML - Brian Niekrewicz, Youri van Dommelen, Thomas Laursen, Robert Watso, John Zimmerman, Aiqin Jiang, Bart Kessels, Sander Bouten, Robert Routh

SEMATECH - Liping Ren

KLA-Tencor - Sumanth Kini, Nithin Yathapu

AMTC - Christian Holfeld, Jan Hendrik Peters

Toppan Photomasks - Brid Connolly

Introduction

- Purpose
  - To get an early understanding of EUVL defectivity
- Process
  - Utilize the equipment and processes of today to understand the consequences for pilot and production tomorrow
  - Baseline and minimize manual reticle handling
  - Baseline Alpha Demo Tool (ADT) contributions

  NOTE: NXE designs remove ADT limitations
- Initial study – reticle particles using wafer inspection
  - The “Defect Mask”
  - Results to date

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Details of this study

- Uncoated quartz substrates are used in baselining
- ASML Alpha Demo Tool [AD1] is located in the CNSE Albany Nanotech Fab North [NFN]
- SEMATECH's Lasertec M1350 is in Nanotech Fab South
  - ☞ 53 nm PSL capability
- Minimized particles from manual reticle handling with optimized procedures
- "Partitioned" particle tests run to determine and minimize contributions from AD1
- Continuing to lower these background particles to enable further studies of EUV defectivity

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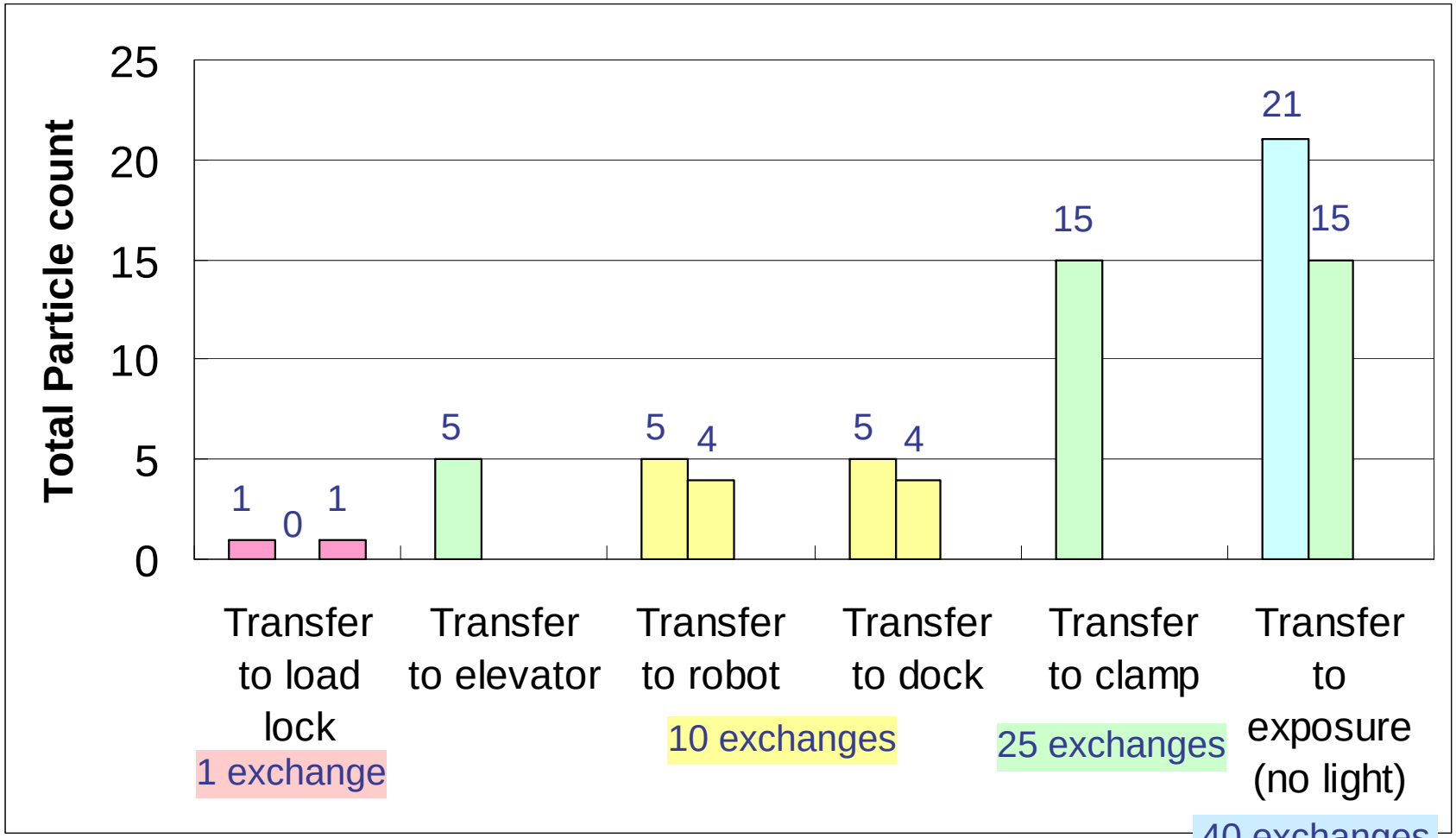
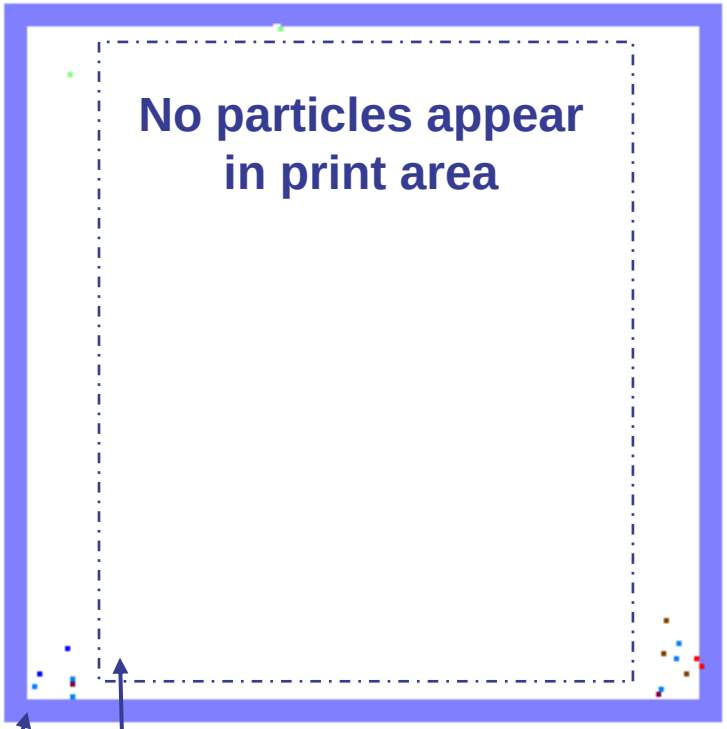
Partition test

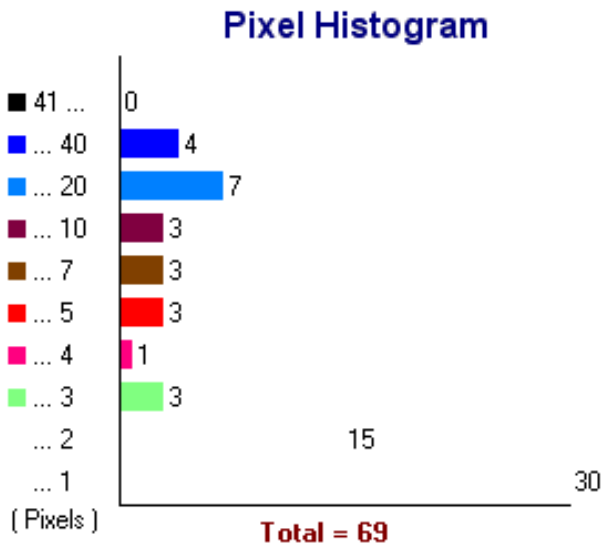
Manual transfer from Lasertec to internal position within AD1

Particle size >53nm



Inspection results show that added particles are concentrated in the corners





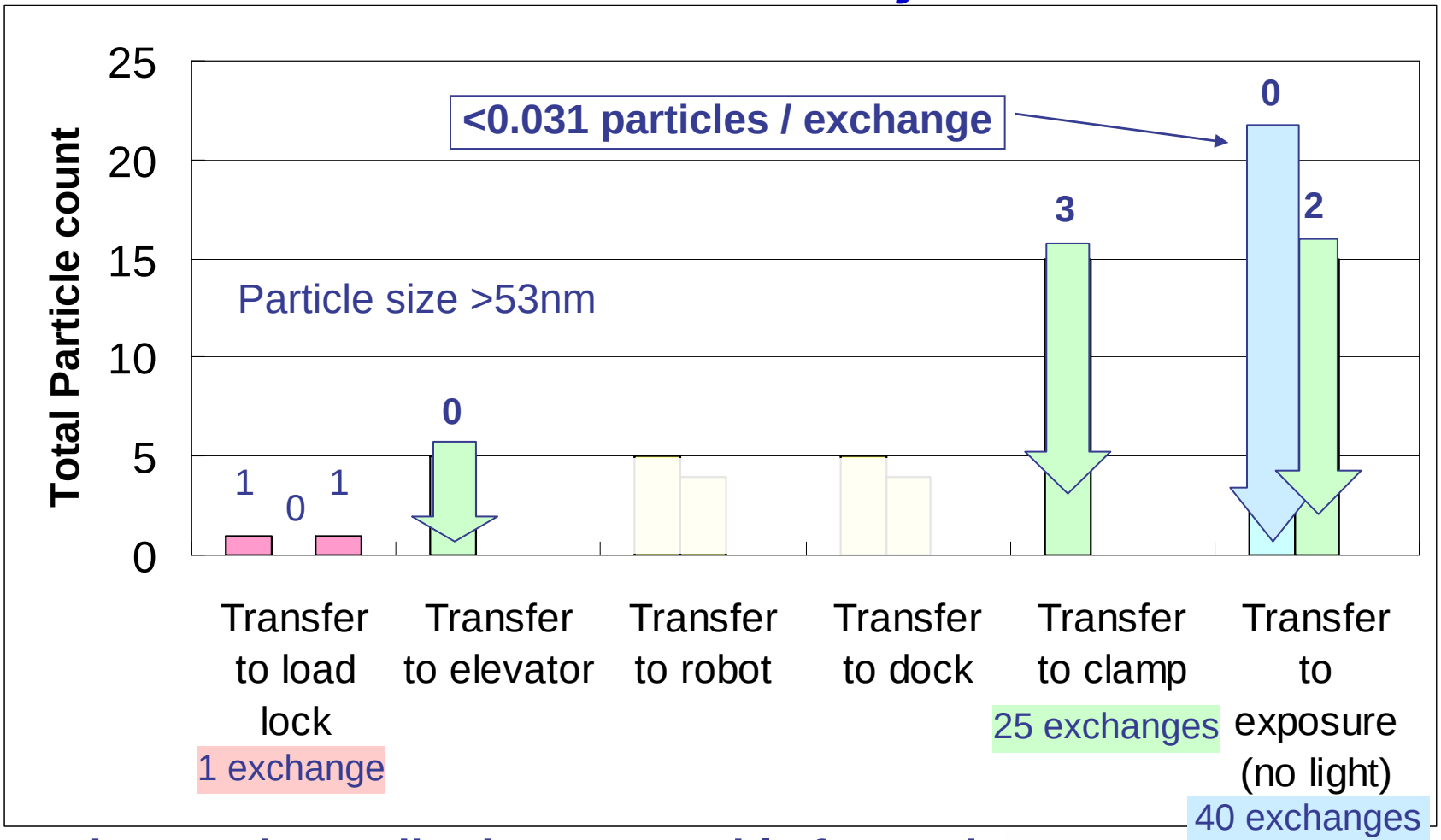
Print area 102 x 132 mm
Quality area 142 x 142 mm

40 cycles
21 particles (bin 4+ is > 53nm)
0.525 particles per pass

Partition test

Manual transfer from Lasertec to internal position within AD1

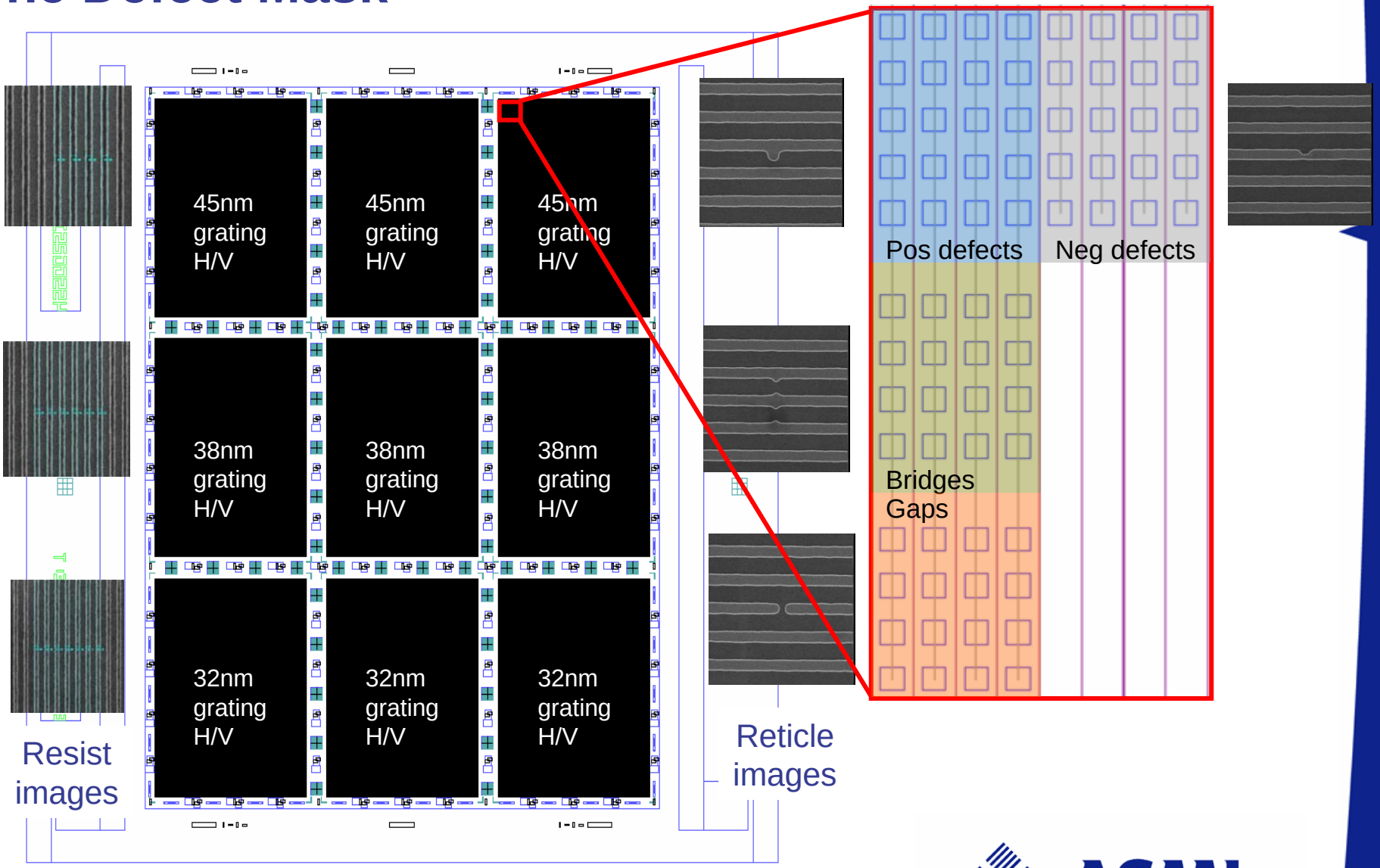
Print area only



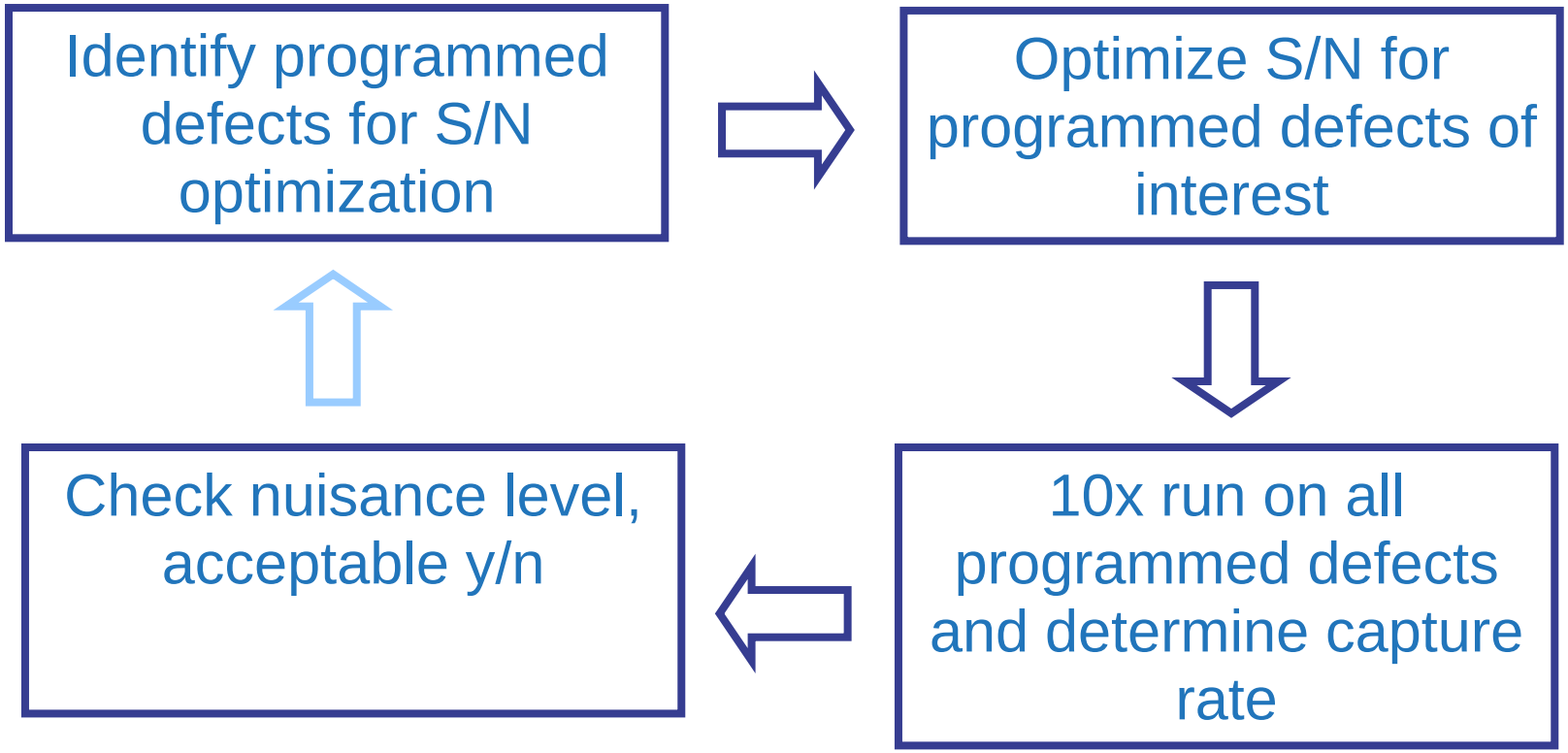
Background contribution acceptable for testing

Initial study – The Defect Mask

Optimize inspection on program defects



Optimization sequence for KLA 2800*



Investigated High throughput, High sensitivity, GHI-Line, Blueband DUV & Broadband DUV

High Sensitivity Blueband DUV & Broadband DUV gave best signal to noise

* Note: 2800 wafer inspector spec'd for 65nm node. Results from current-gen tool may differ

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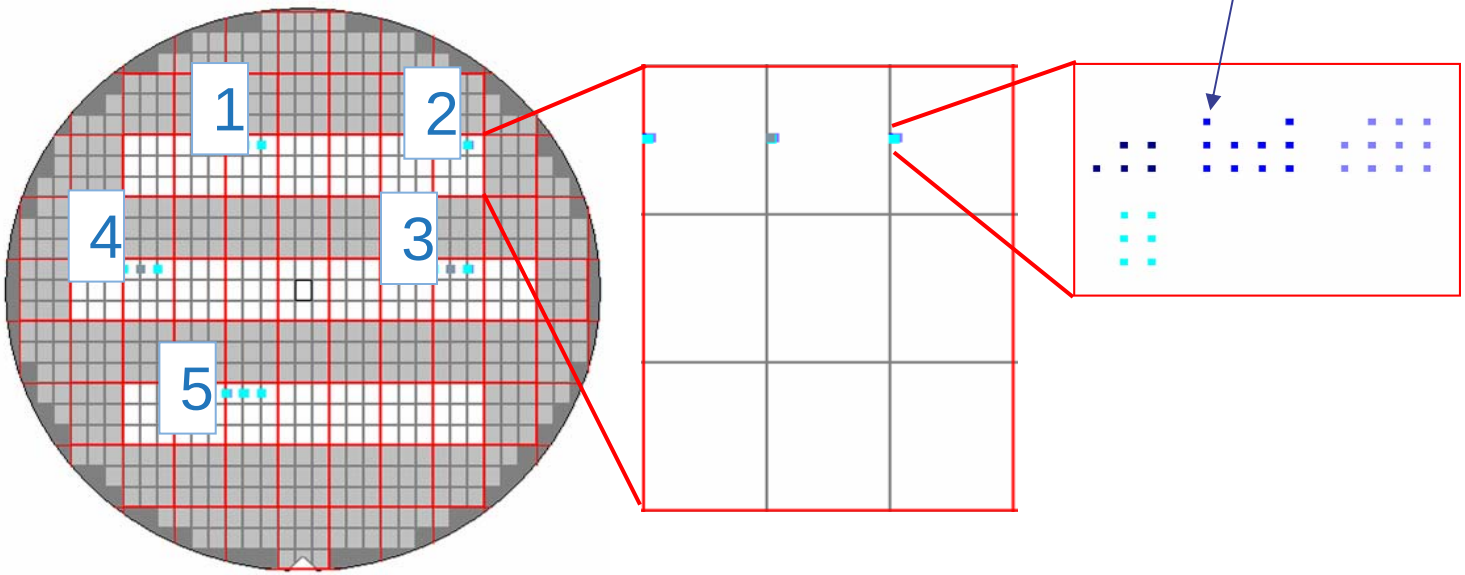
Capture rate on programmed defects

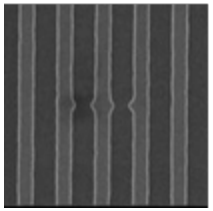
- Measure 5 fields on KLA2800, repeat 10x
  - 4 sets of programmed defects per field (bridge, gap, neg & pos defect)
  - Each repeater should show up 10x, if capture rate = 100%

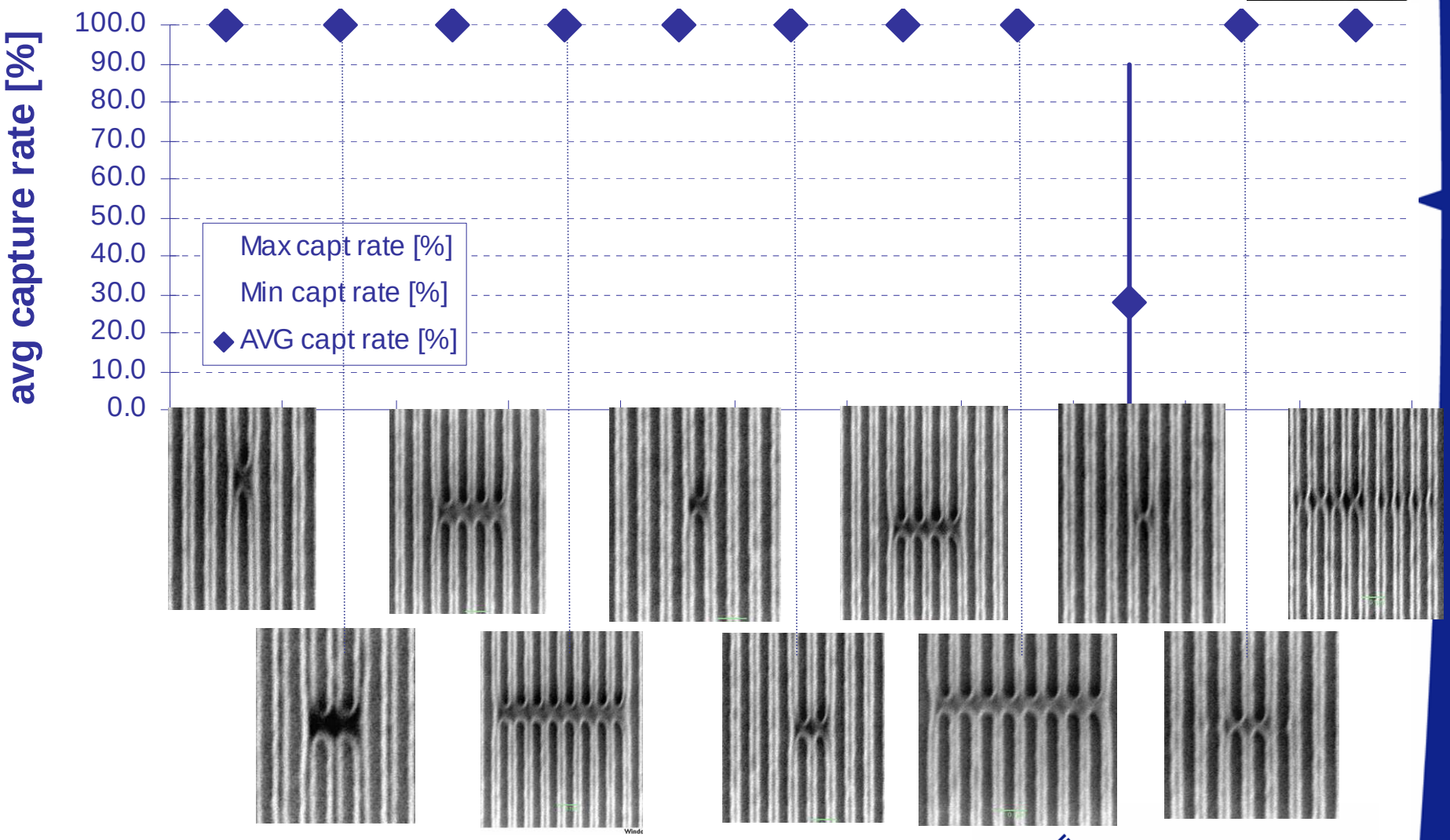


Example for 45nm features

Capture rate on programmed defects, 32nm features

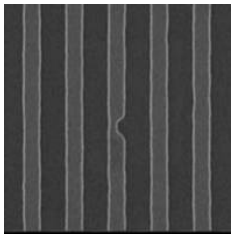
Bridges, avg capture rate (5 flds, 10rpts/fld)

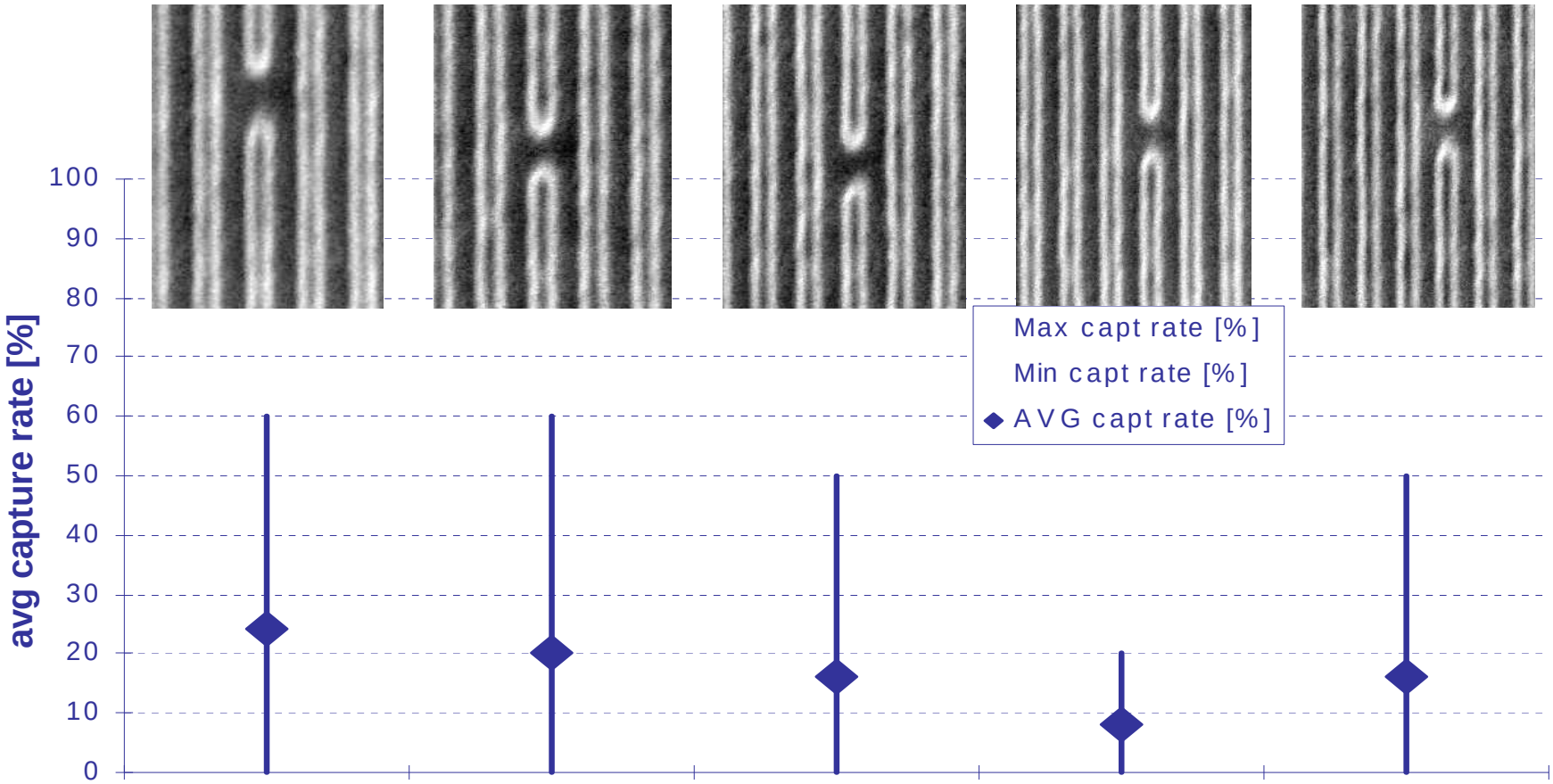




Capture rate on programmed defects, 32nm features

Neg. defects, avg capture rate (5 flds, 10rpts/fld)





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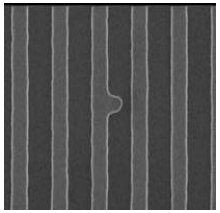
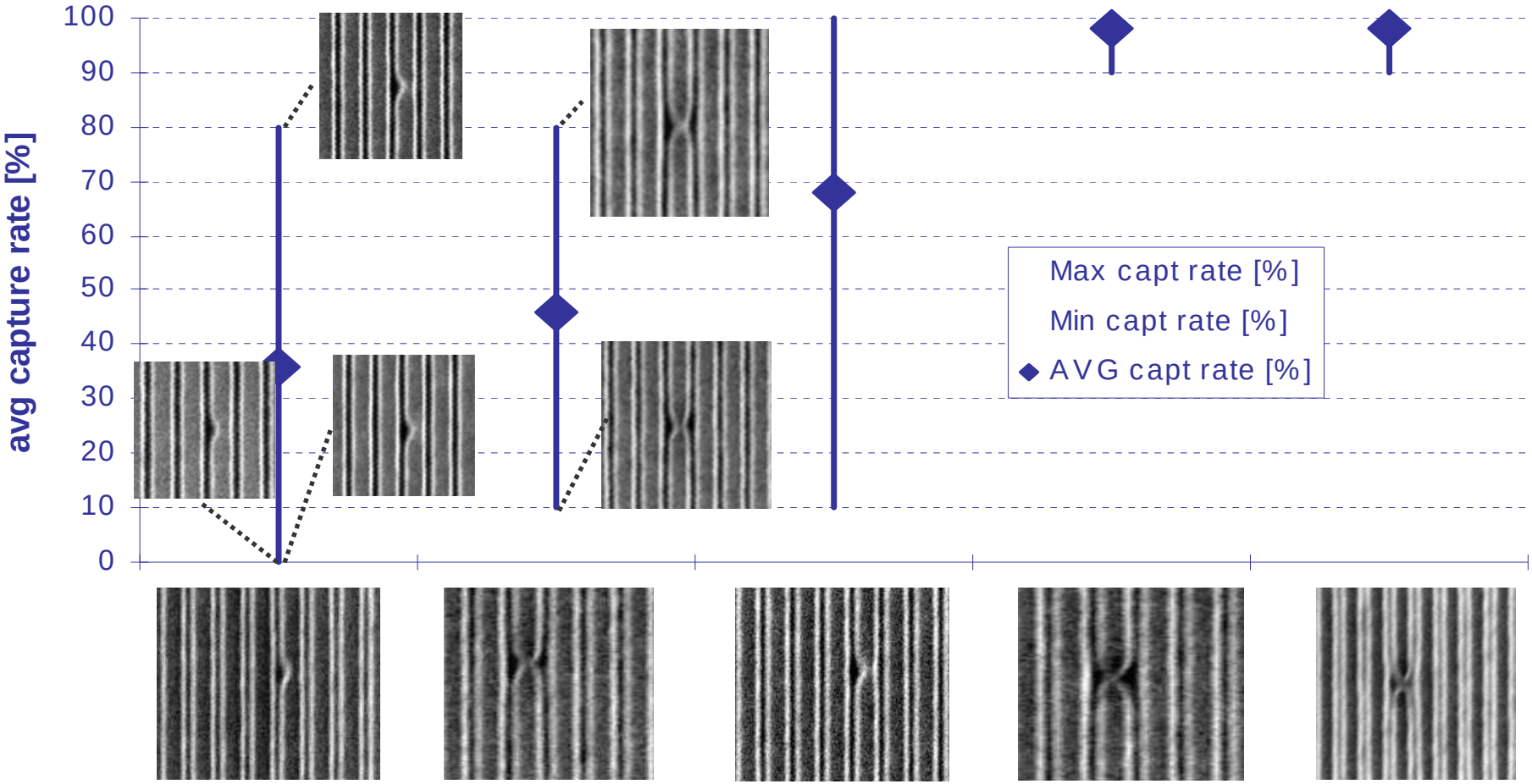
Capture rate not related to feature size

Only plotting capture rates < 100%

***Positive defects**, avg capture rate (5 flds, 10rpts/fld)*



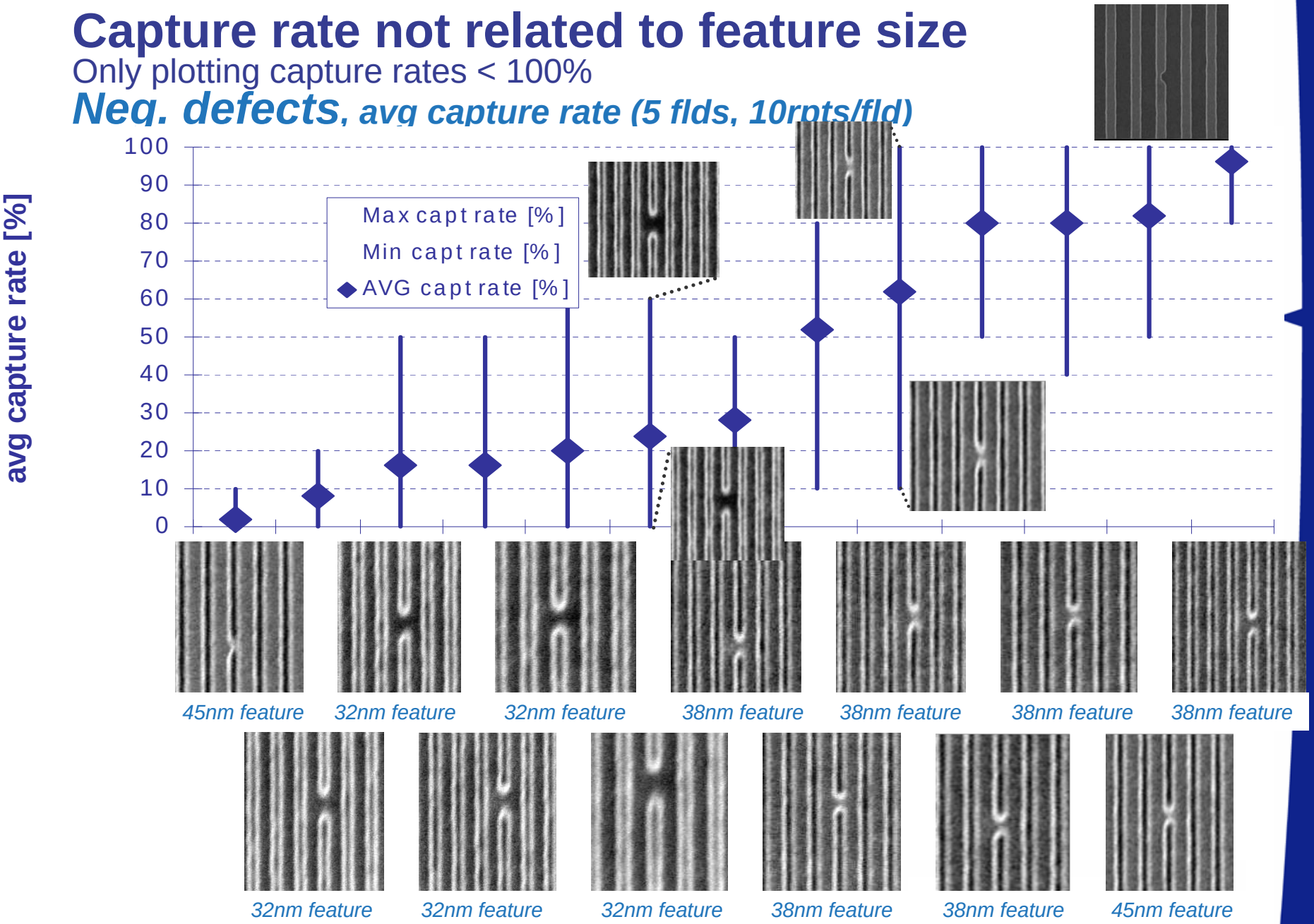


ASML

Capture rate not related to feature size

Only plotting capture rates < 100%

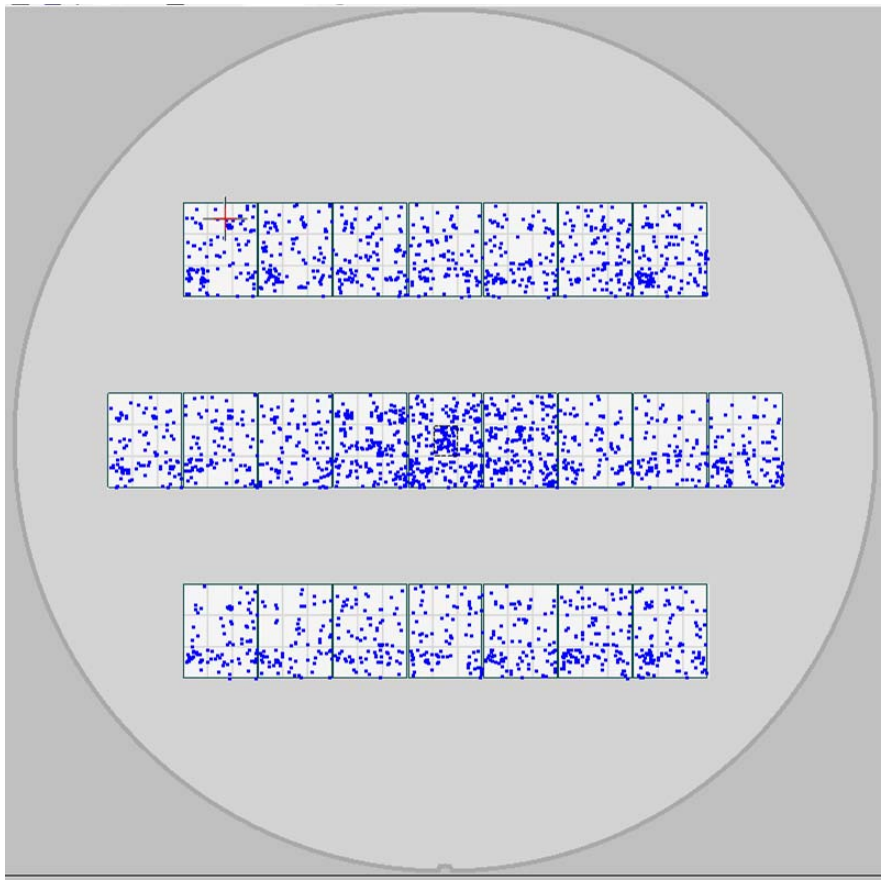
Neg. defects*, *avg capture rate (5 flds, 10rpts/fld)



1st defect data measured – no optimization or tweaking

- Random defects from 23 fields exposed on EUV AD1 and measured on KLA2800
- Remove reticle and programmed defects
- SEM review

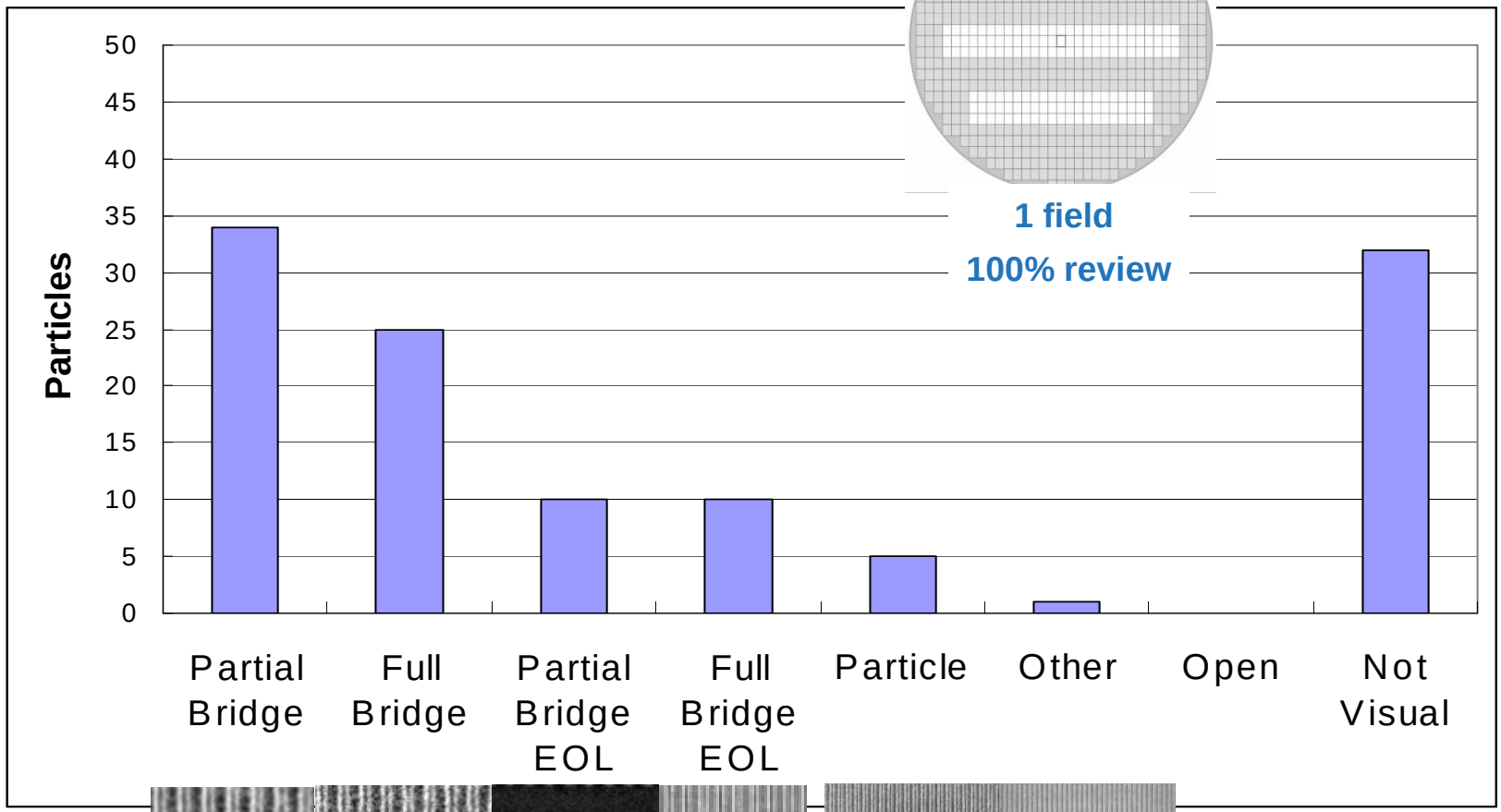
Random defects - raw data

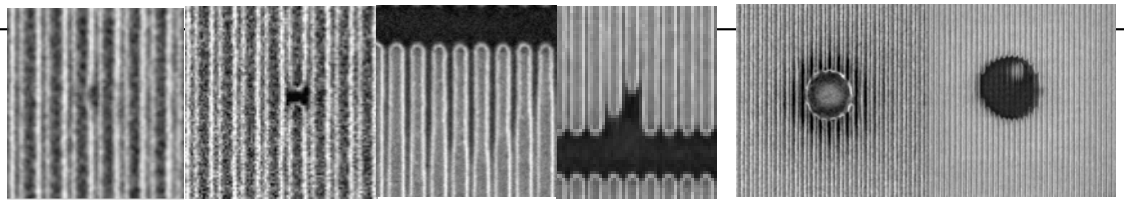


Count : 3134

Defect pareto

Random defects





NV = 27%

Summary

- Manual transfer of reticles is possible at rates as low as 0.03 particles (per reticle exchange/exposure)
  - Allows meaningful defect work using today's limitations
  - Work continues to reduce particle number further
- Printed capture rate vs defect size is different for feature types
  - Cannot "simply" state capture rate vs defect size
  - Here capture rate seems to be independent of feature size
    - Caveat: - KLA2800 is spec'd for 65nm node. Future studies using current-generation wafer inspector may reveal different trends
  - Determining reticle defects from wafers is complex
    - Industry coordination/cooperation would be beneficial
- Initial random defect data set shows = ~14 defects /cm^2
  - First look and "as is" – no optimizations
  - Majority of these defects are bridges
  - Nuisance level 27%
- Continuing reticle-wafer defect printability studies

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