

Improvements of Multi-Layer Defect Mapping with Advanced Inspection Technology

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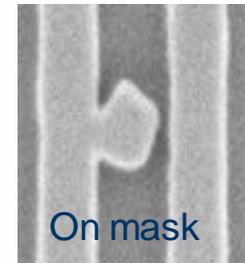
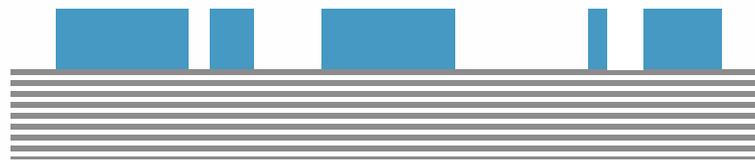


Problem Statement and Objective



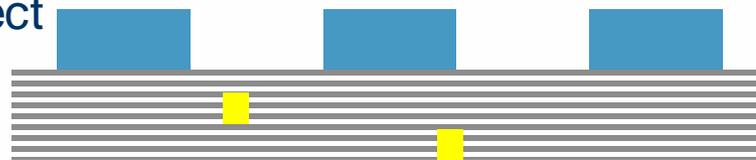
- **Problem Statement:** Most probably not all multi layer (ML) defects are discovered by the current generation of blank inspection (BI) tools¹
- **Objective:** Find evidence for multilayer defects, not discovered on blank, by advanced patterned mask and wafer inspections (PMI and WI)

Absorber defect
opaque or clear



All printing absorber defects can be found by PMI²

Multi-layer (ML) defect
*cause in the ML
or on the substrate*



Mo
Ru
Silicon



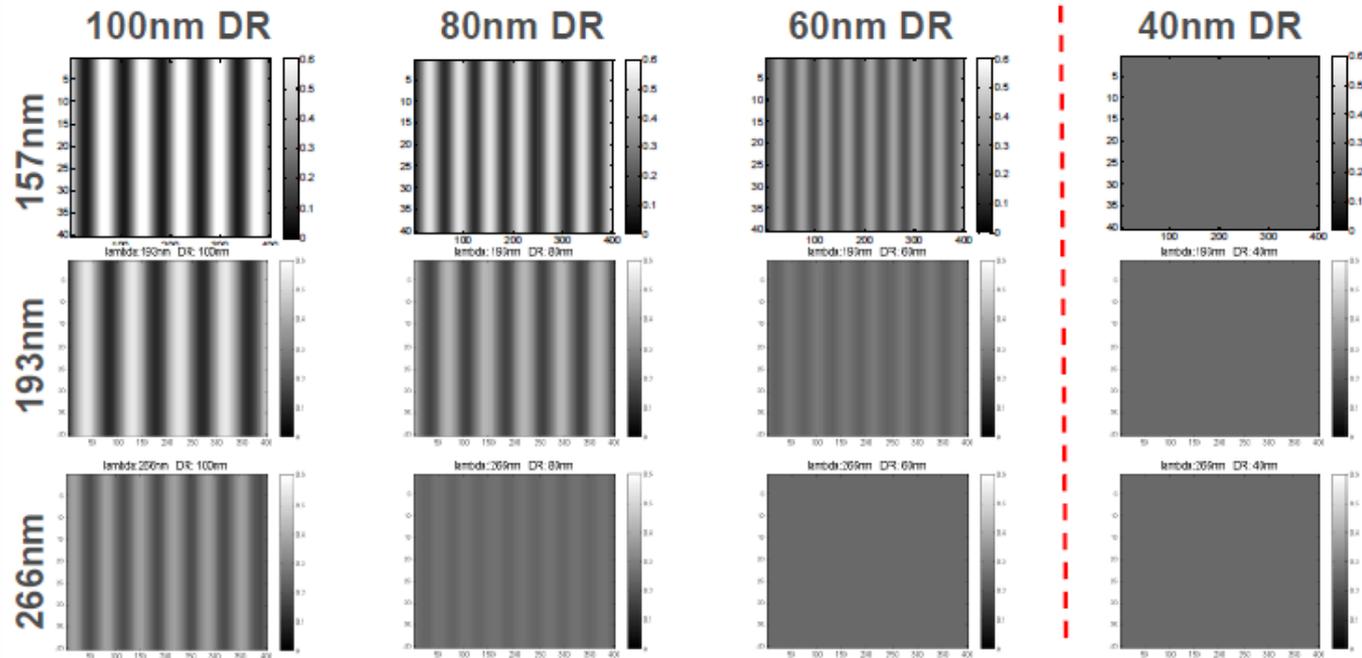
Printing absorber and ML defects can be found by WI²

¹ Proc. EMLC7985, 2011, "Evidence of printing blank-related defects on EUV masks, missed by blank inspection"

² Proc. SPIE7823, 2010, "EUV mask defectivity study by existing DUV tools and new E-beam technology"

Wafer Inspection Resolution Road Block

Bright field is limited by low contrast



40nm design rule is the bright field resolution limit for all applicable wavelengths

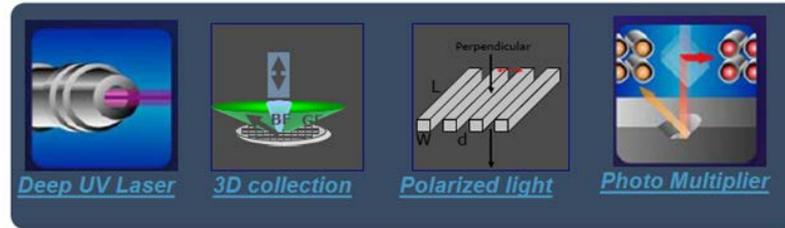
UVision5 Wafer Inspection



Beyond end of resolution limits: Grey Field (GF)

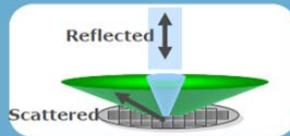
Key features:

- Smaller pixel sizes with high throughput (260..70nm, 10.2..1.7wph)
- Increased light in the Grey field channel :



UVision has DUV Laser for optimum brightness, and 3D PMT detectors for optimum SNR and collection of the scattered light

- Detection is not limited by resolution
- Signal-to-noise ratio (SNR) determines sensitivity
- Scattered light intensity $\sim 1/\lambda^4$



SEM Image



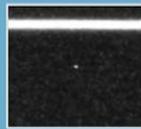
40nm defect

BF



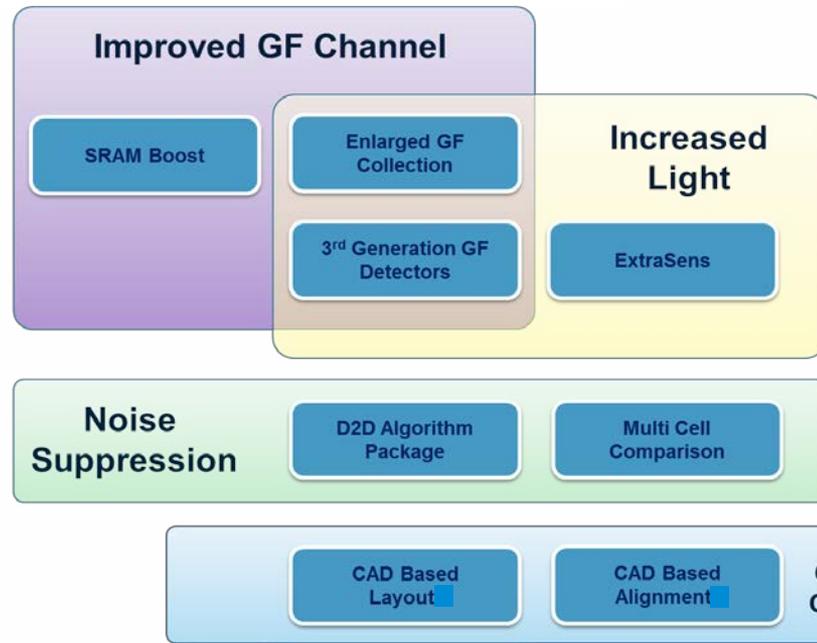
No Resolution

3D



SNR 25

- Wide dynamic range detectors
- And innovative noise reduction



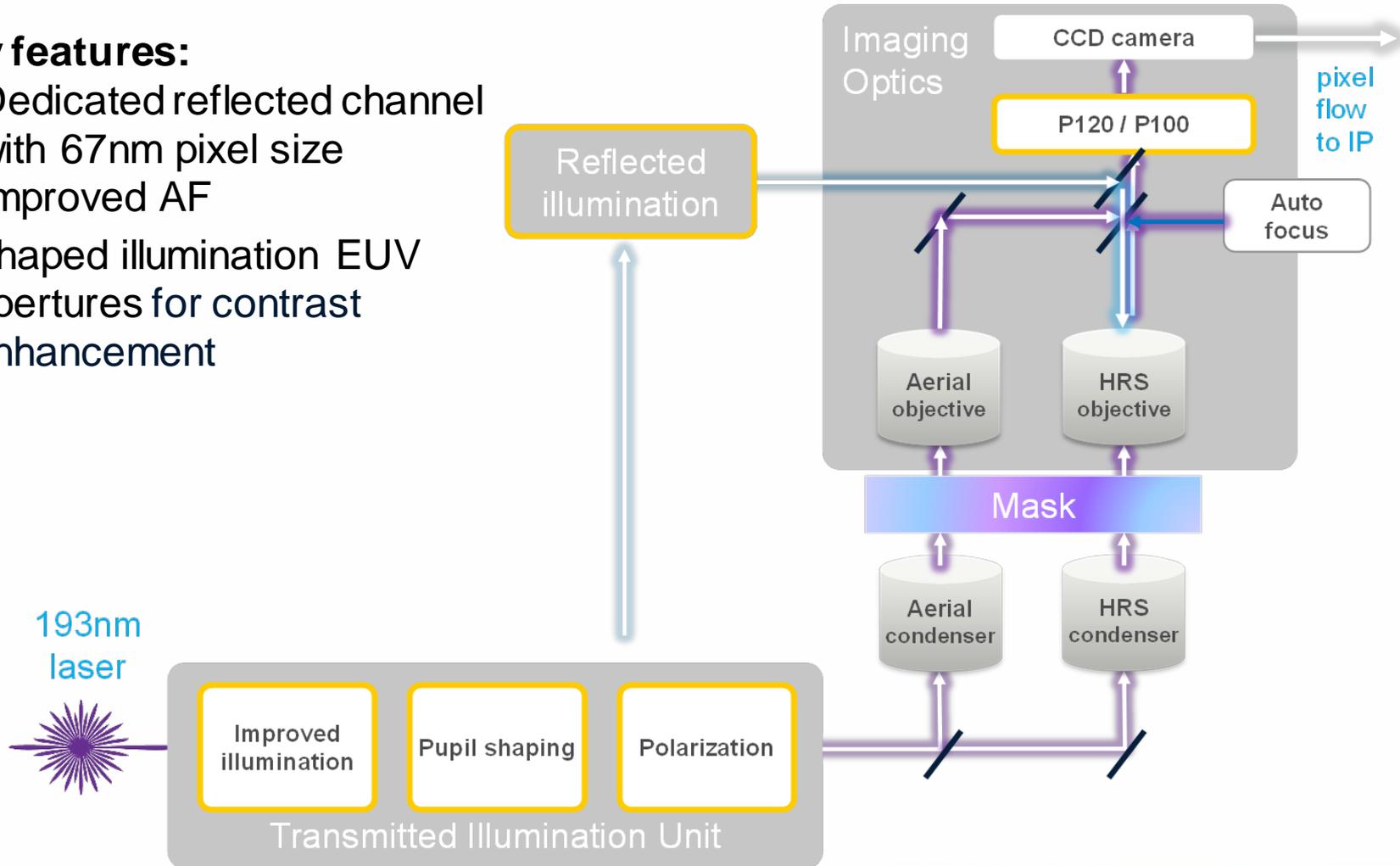


Aera3 EUV Mask Inspection

Enhanced sensitivity: reflective path smaller pixels

Key features:

- Dedicated reflected channel with 67nm pixel size
- Improved AF
- Shaped illumination EUV apertures for contrast enhancement

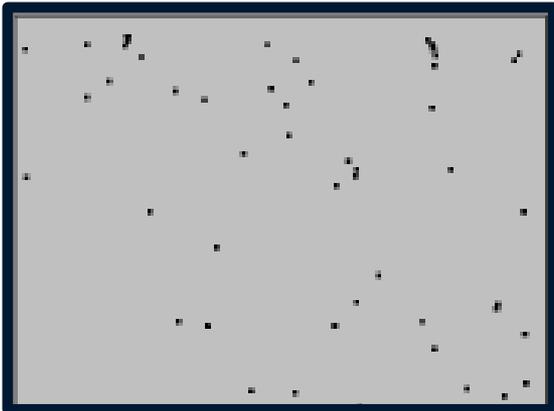


Advanced Inspection Technology



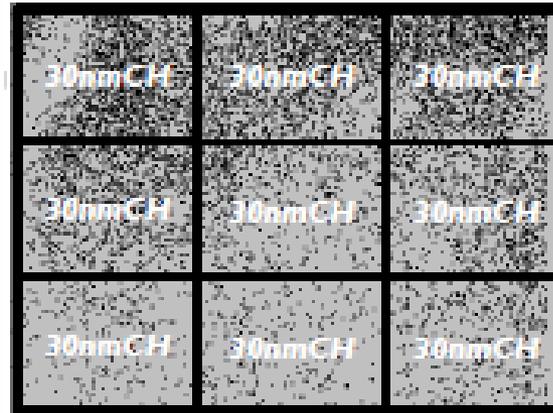
for multi-layer defects detection; experimented on 30nm CH mask

Patterned wafer inspections finds absorber and multi-layer defects



UV5 **WI** :
Repeater analysis

Patterned mask inspections finds **all printing** absorber defects



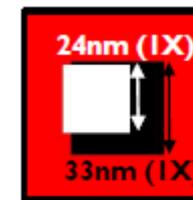
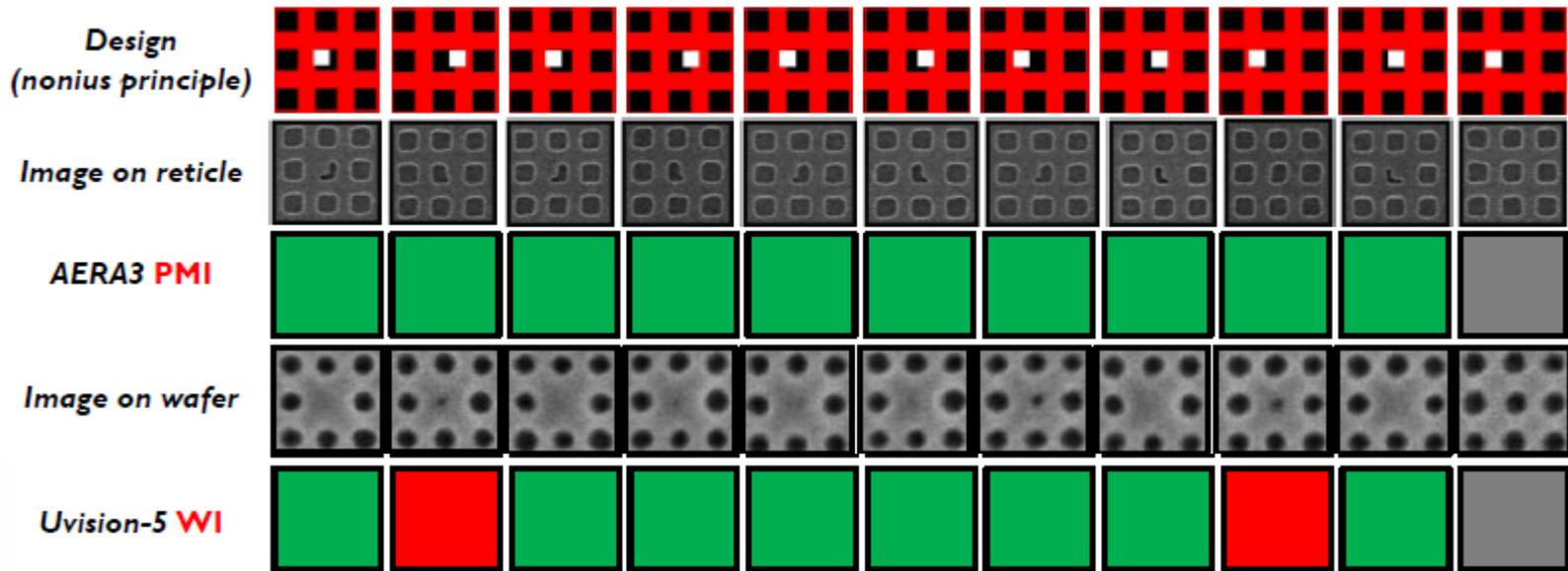
Aera3 **PMI** :
Die-to-Die

Pure
Multi-layer
Defects
Bin (which
added to
the blank
inspection
results)

Results: Programmed Defects



UVision5 and Aera3 performance on program opaque absorber defects

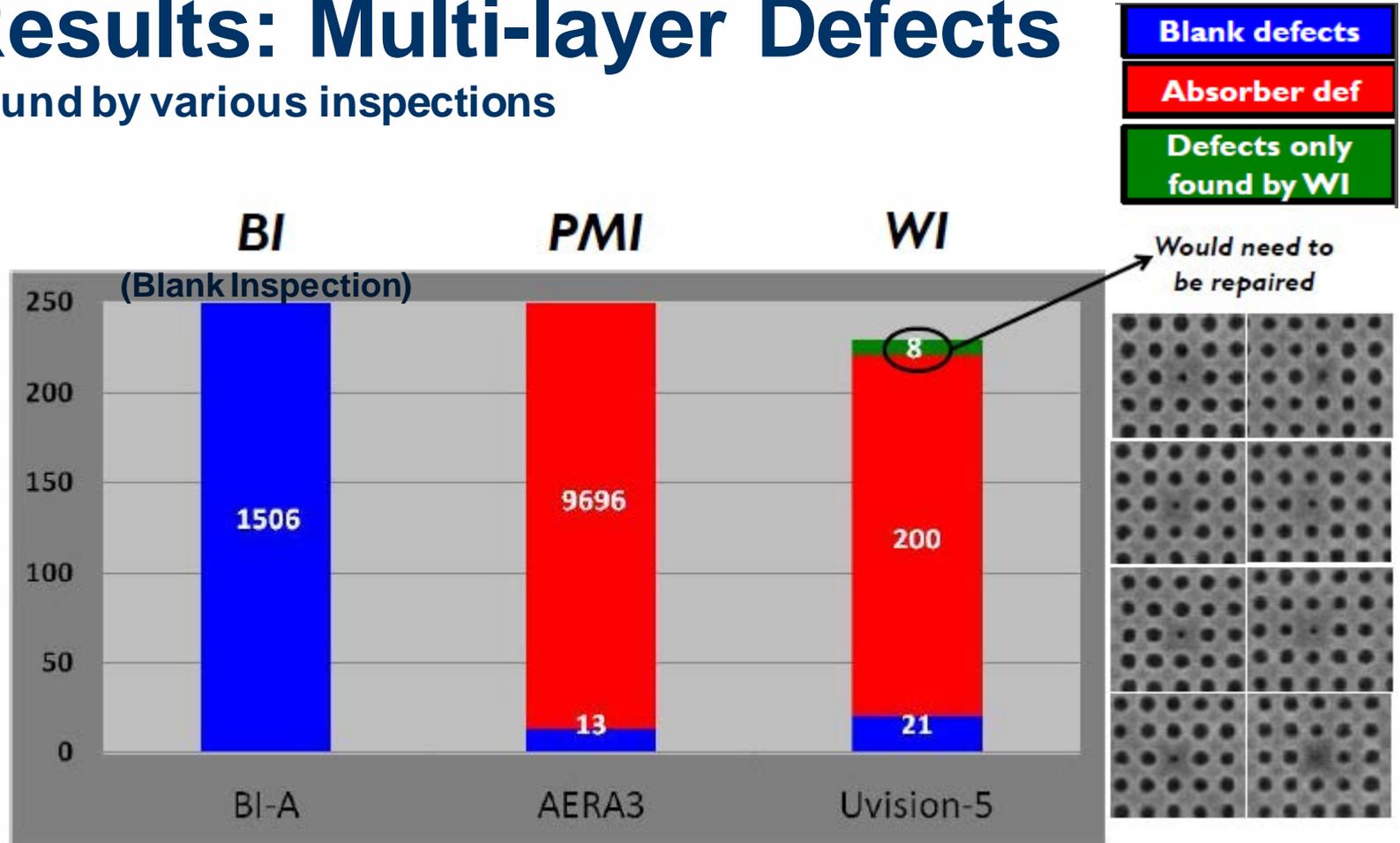


Detected
Not detected
Does not print

Both UVision5 and Aera3 are capable for detecting challenging printing absorber originated defects

Results: Multi-layer Defects

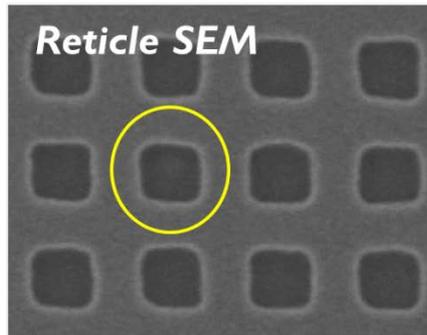
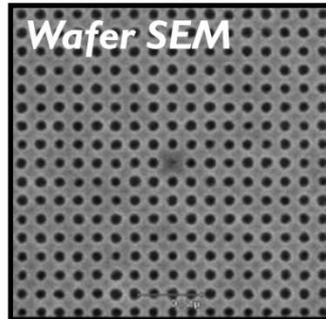
Found by various inspections



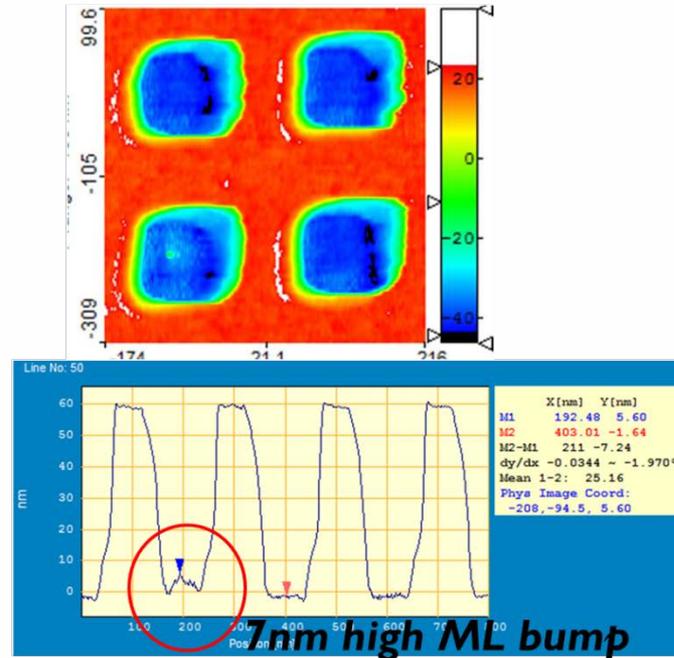
8 additional repairable Multi-layer defects detected by UVision5 (confirmed by mask SEM and AFM) which had not been obtained by BI and PMI

UVision5 Unique Multi-layer Defects

Defects Compensation repair



Review with Integrated AFM



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*see D. Van den Heuvel (imec), Session 4, Tuesday 9.40

Possible device killer Multi-layer defects, discovered only by WI, are being repaired



Summary

- ✓ Uvision5 and Aera3 advanced inspection technologies for wafer and mask were proven effective for multi-layer defects detection of 30nm CH node EUV mask
- ✓ 8 additional multi-layer defects were discovered vs. blank inspection base line and repaired*

*see D. Van den Heuvel (imec), Session 4, Tuesday 9.40



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APPLIED MATERIALS.