ML Defect Integrated Solution Demonstration

2/21/2010

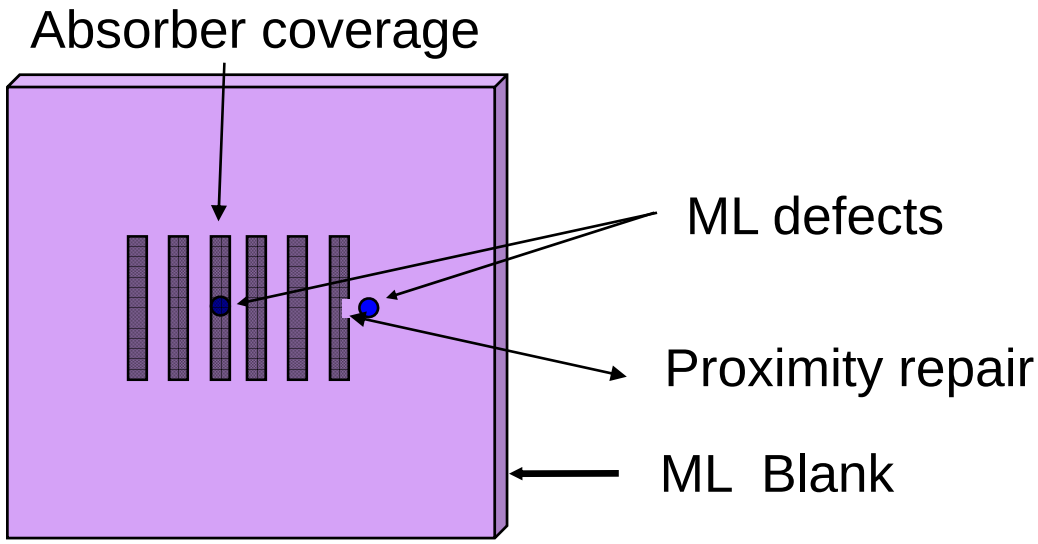
Outline

1. Background Information
2. Zero printable ML defect demonstration
3. Summary

Background Information

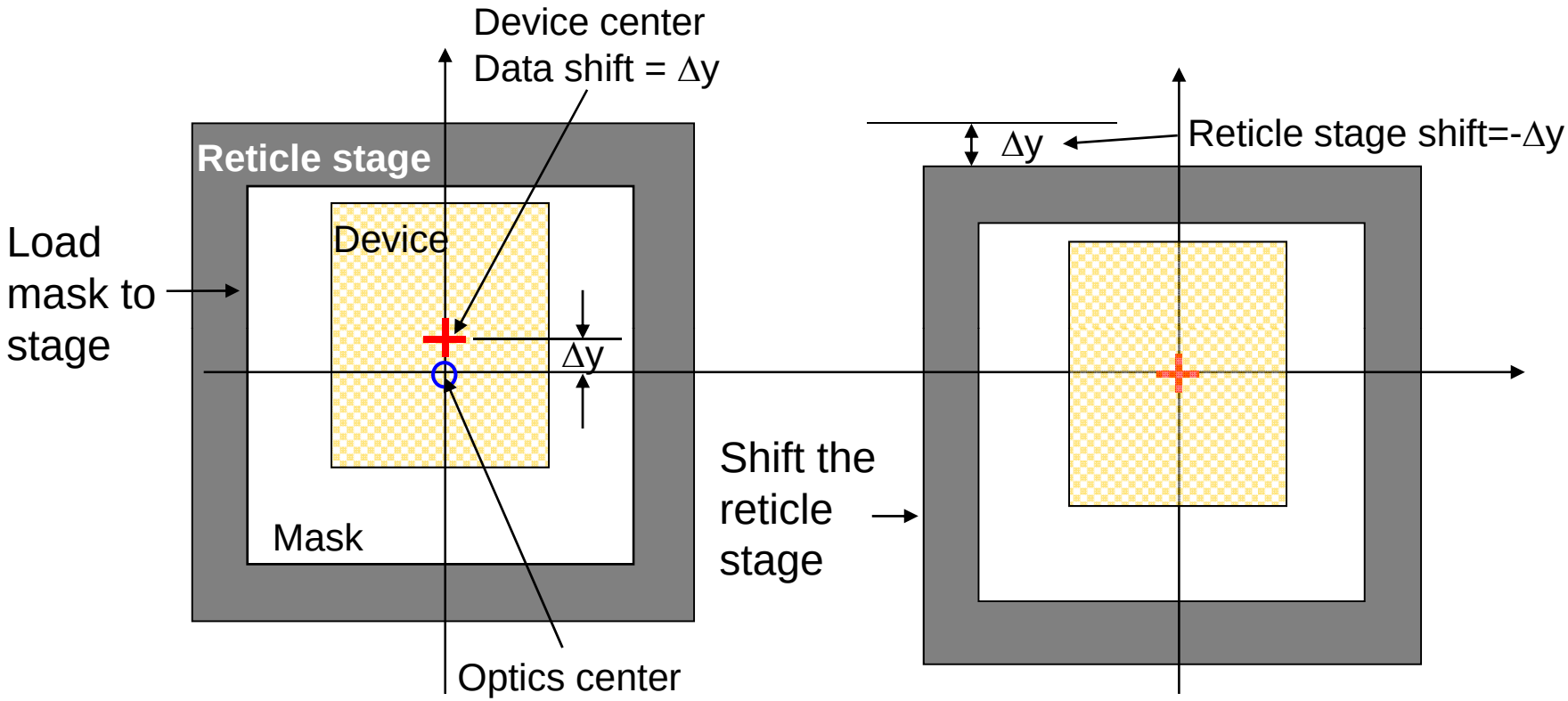
- **Why ML defect mitigation is needed?**
  - Due to concerns on availability of defect-free EUVL ML blanks
- **How is ML defect mitigation achieved?**
  - ML sorting for suitability of different mask layers (e.g., defect requirement for the dark filed contact layer will be different from that of poly layer)
  - Using absorber pattern to cover ML defects via pattern global x- and y-shifting
  - ML defect proximity repair after patterning

Examples of ML defect covered by absorber & mitigated via proximity absorber repair



Background Information (cont'd)

Example of Pattern Shifted Mask at Scanner
(Δy shift only as an illustration)



1. Load/align the mask as usual (please note that only device data are shifted, reticle alignment mark/ PPF does not shift). Mask is centered on the stage
2. Input Δy shift in scanner to shift the reticle stage by -Δy such that device center matches to scanner optics center
3. Print wafer

Background Information (cont'd)

Zero Pintable ML Defect Integrated Solution

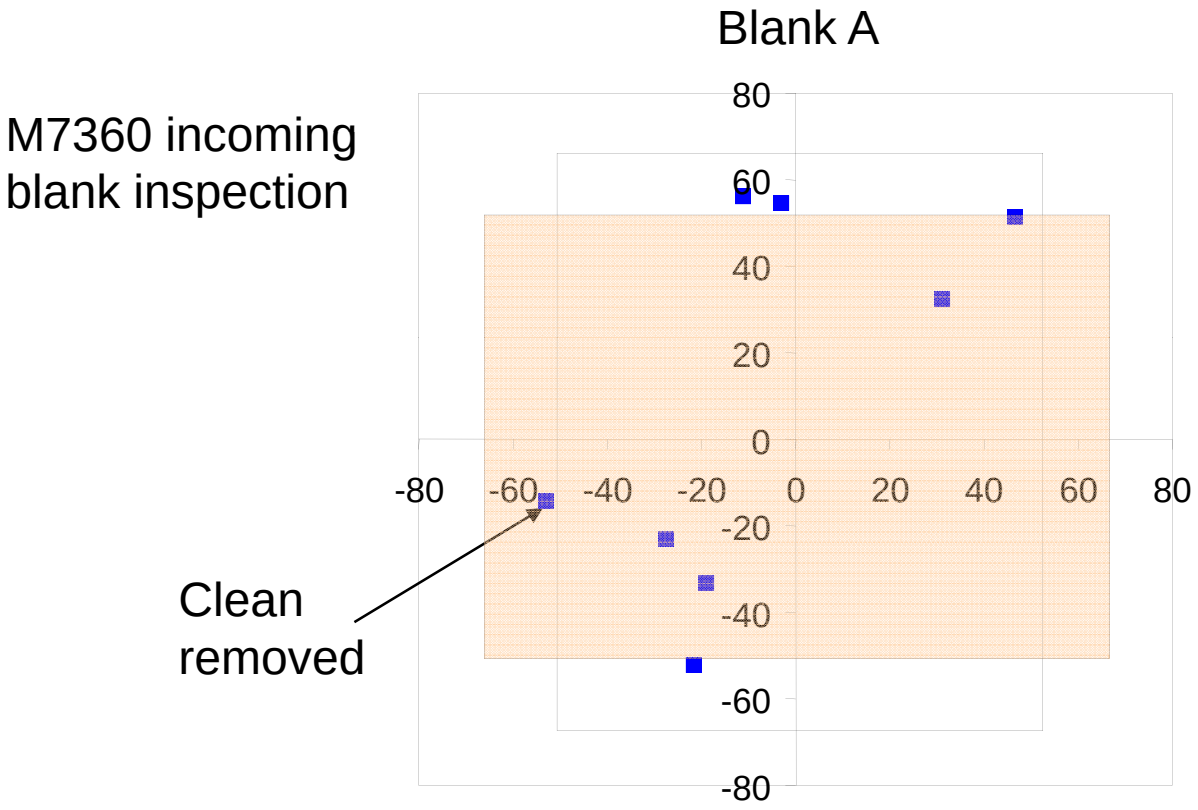
Solution: Combine low defect ML with absorber covering scheme

Goal: No printable ML defects on the finished EUVL mask

- Zero printable ML defect in final mask is likely achievable if
  - ML blank has only a few printable defects
  - Mask has high/low pattern density

- It requires several key capabilities (long term solution)
  - ML with a few printable defects
  - Fiducial mark standardization
  - ML blanks with fiducial marks that meet SEMI-standard
  - High defect inspection tool stage precision and accuracy
  - Auto mask pattern shift software
  - EUV AIMS tool for proximity repair and final defect mitigation verification

Demonstration Step 1: Select Lowest Defect Blank & Determine Preferred Orientation

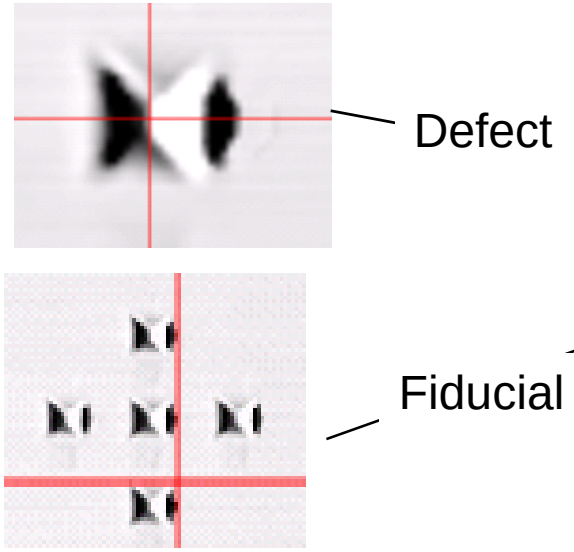


- Blank has total of 8 defects ≥70 in 132x132mm^2 and 3 defects in the device area with preferred horizontal rotation.

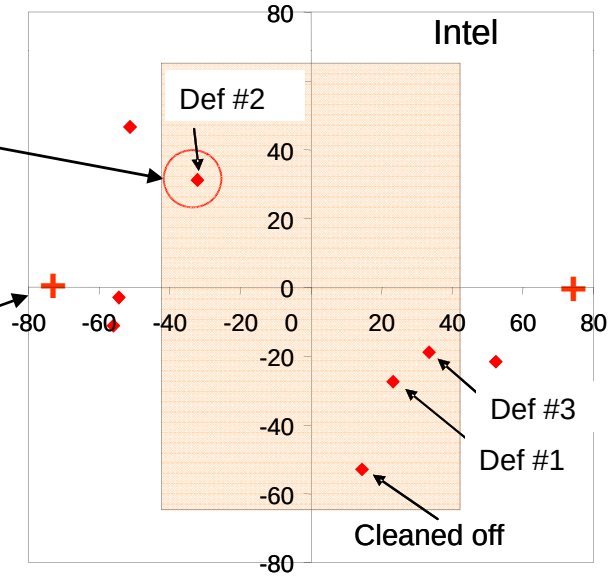
Step 2: Select another ML Blank and Create Fiducial/ML Defects to Mimic Blank A

(to save blank A for actual mask fabrication)

Mark defects with locations identical to that of blank A

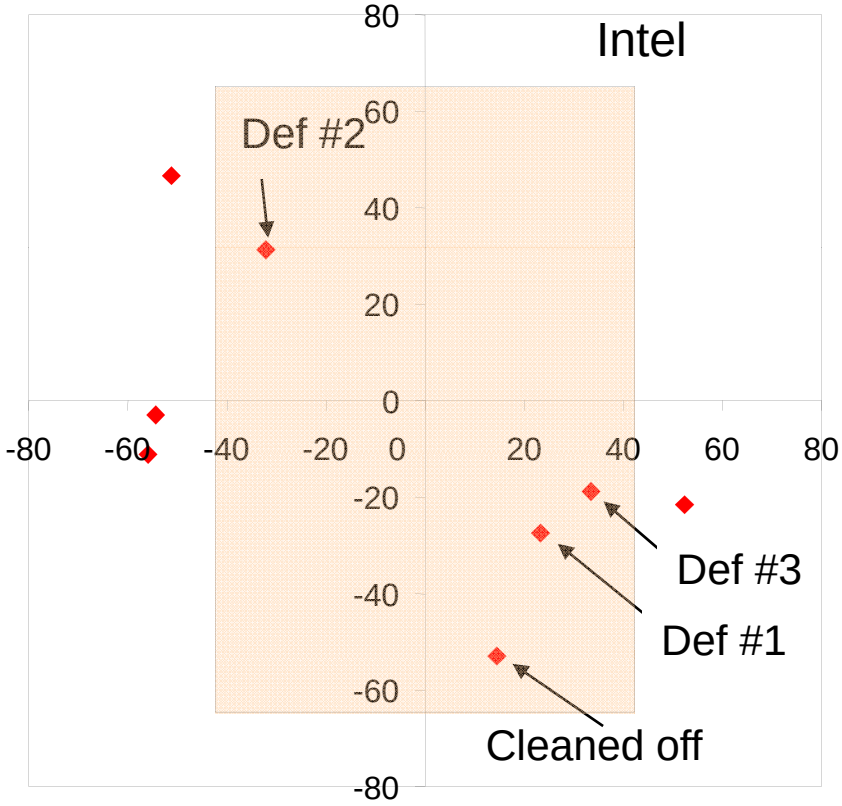


3 defects are within pattern field for indicated blank orientation



Step 3: Deposit TaN and Pattern E-beam Alignment Marks

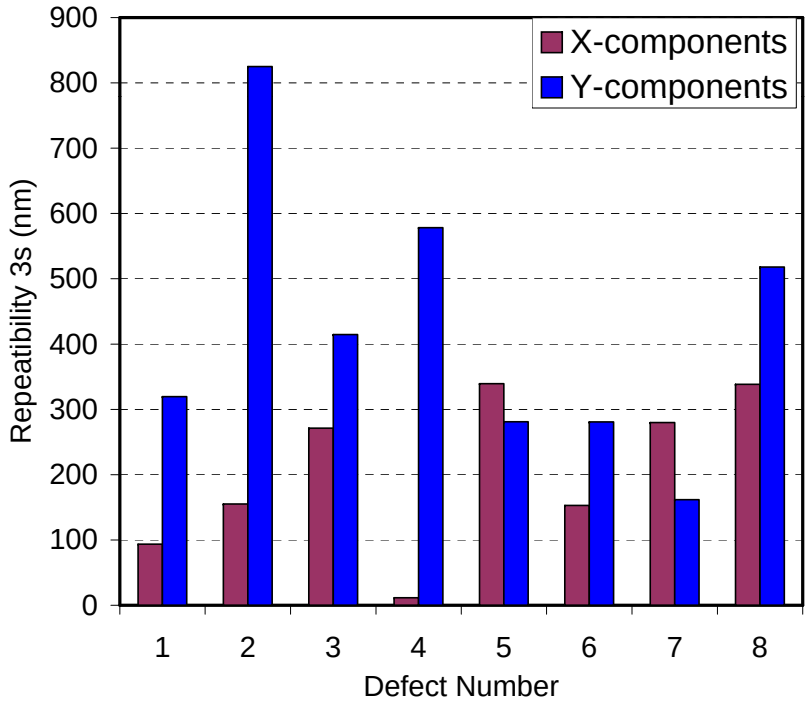
Def ID	X (µm)	Y (µm)
Def #1	23297.452	-27446.091
Def #2	33496.472	-18678.988
Def #3	-32152.748	31213.513



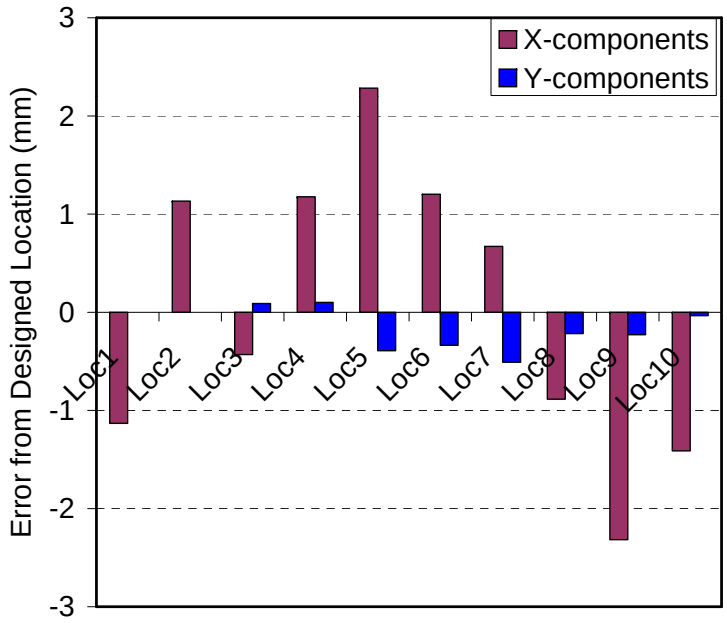
Step 4: Determine Defect Location Correlation to E-beam Mark

1. We first measured locations via M1350, found ~800nm repeatability error .
2. Then measured known e-beam patterned locations, found >2μm accuracy error

M1350 defect location repeatability (3 measurements)



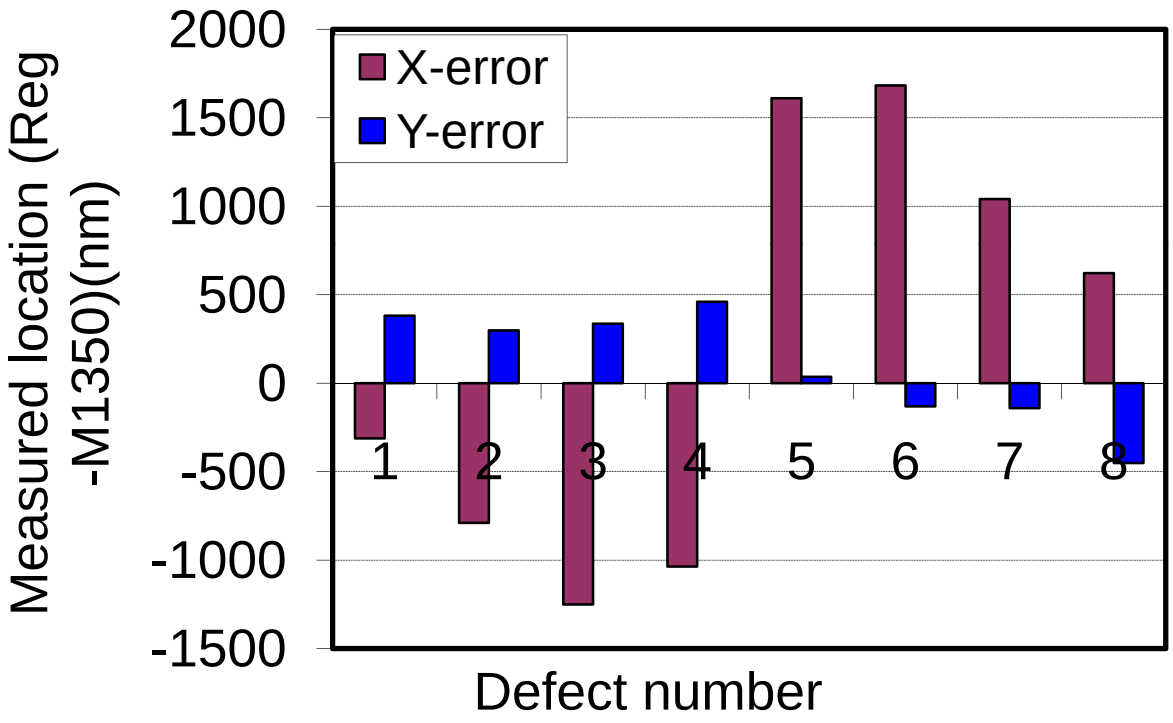
M1350 measurement vs. designed location (e-beam stage error neglected)



➢ Defect location measurement error in M1350 found are not acceptable.

Re-measured Defect Locations Using a Mask Registration Tool

Position difference found between registration tool and M1350



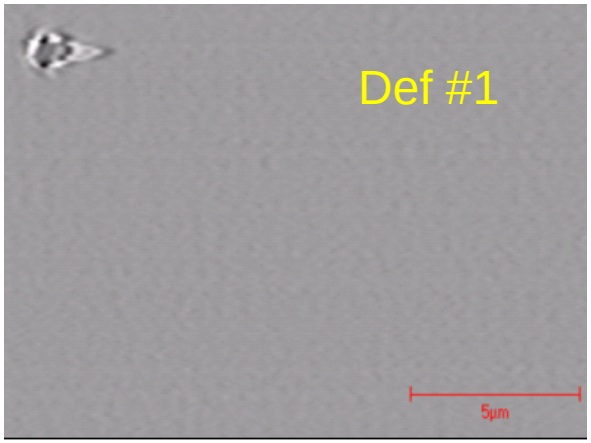
- The registration tool measurement were assumed to be accurate and are used in the experiment.

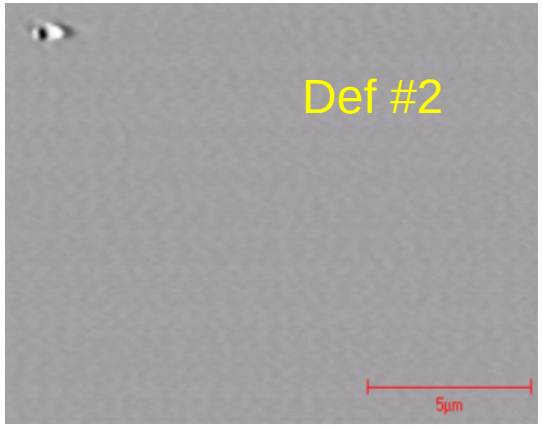
Step 5: Estimate Defect Size and Determine Required Absorber Pad Size

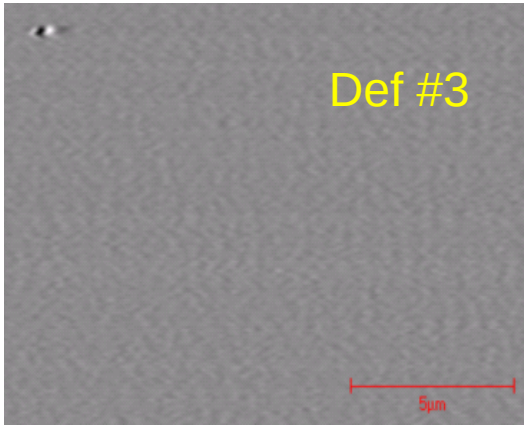
Optical image ~2μm
M7360 pixel 41

Optical Image ~0.5μm
M7360 pixel 22
SiO_2 equivalent: 120μm

Optical Image~0.3μm
M7360 pixel 14
SiO_2 equivalent: 75nm



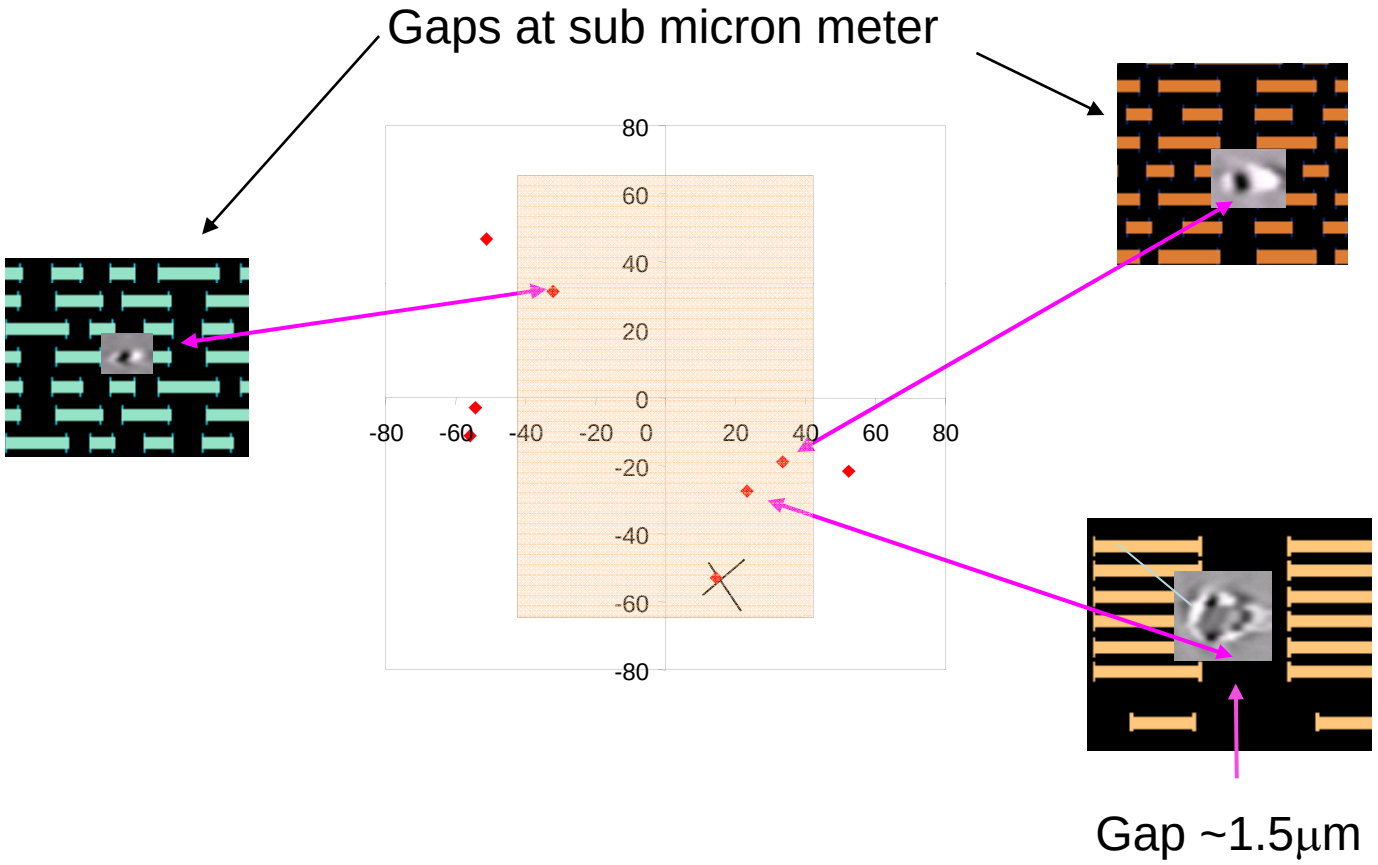




- Optical image seems to estimate larger defect size than that of M7360 calibrated SiO_2 equivalent size
- Based on the optical image estimated defect size, we would need absorber pad sizes of 2.5-3.0μm, 1.0-1.5μm, and ~1.0μm sizes for defect #1, #2, and #3, respectively, given possible alignment error + defect location measurement error.

All 3 Defects are Found at Close Proximity of the Full Field Test Device Pattern

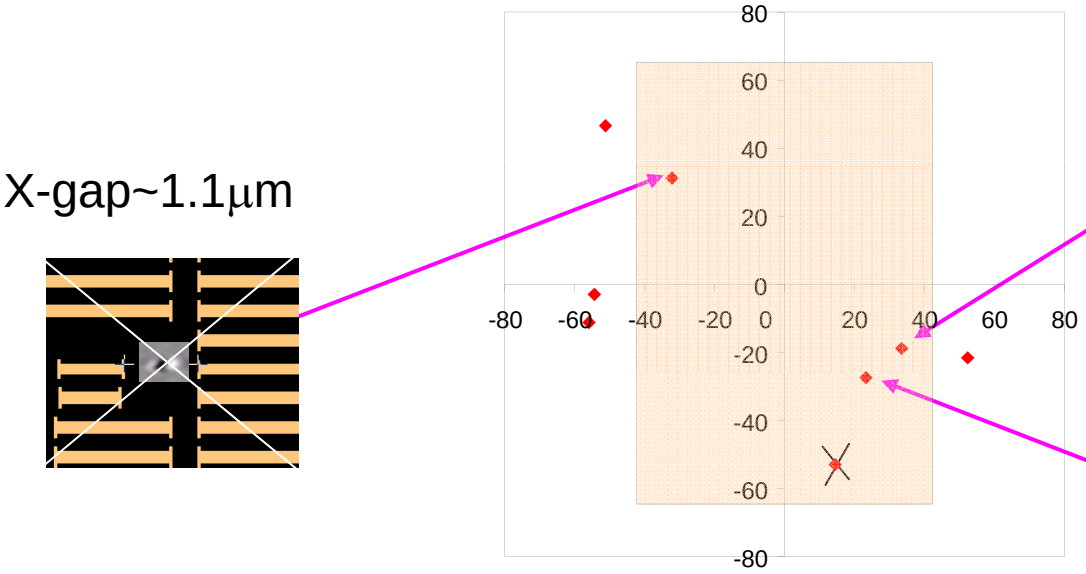
-field size (4x) ~90mmx120mm



- If no mitigation scheme applied, all defects are expected to be printable.

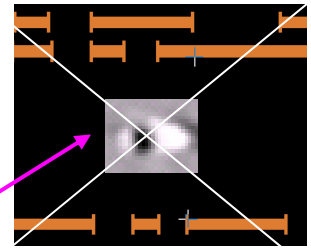
Step 6: Pattern Shift Solution to Cover All 3 Defects was Found

x-shfit	y-shift
-42.55um	423.737um

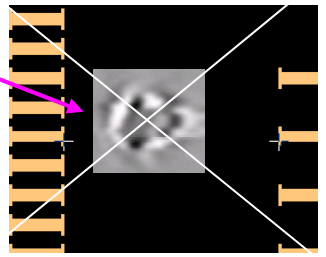


X-gap~1.1μm

Y-gap~2.5μm

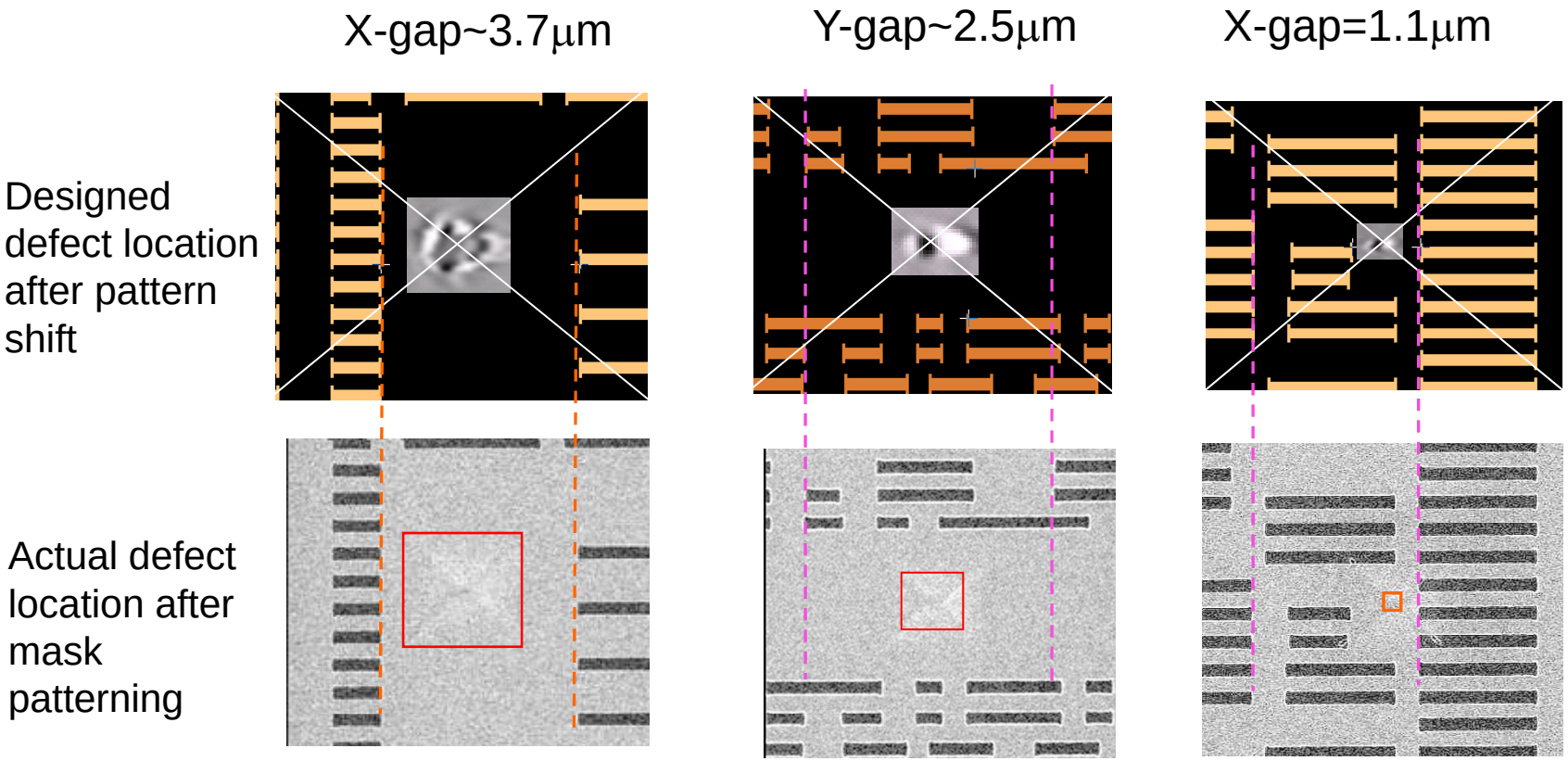


X-gap~3.7μm



- If defects are successfully covered, they are expected non-printable.

Results:
Pattern Shift Solution Verified in Final Mask



- All three defects are successfully covered as designed with negligible errors.
- All three defects at different sizes (as indicated by the red boxes) are successfully covered with additional margins.

Conclusions

ML defect mitigation solution with full field pattern demonstrated

- All three defects are successfully covered by absorber with negligible error and extra margins.
  - Key successful factor is the defect location and fiducial mark location measurement accuracy
- Such complete coverage will lead to ML defect free printing.

Acknowledgement

Guojing Zhang , Marilyn Kamna, Ken Buckmann, and Yan Liu