Strawman alignment error budgets for implementing fiducial marks

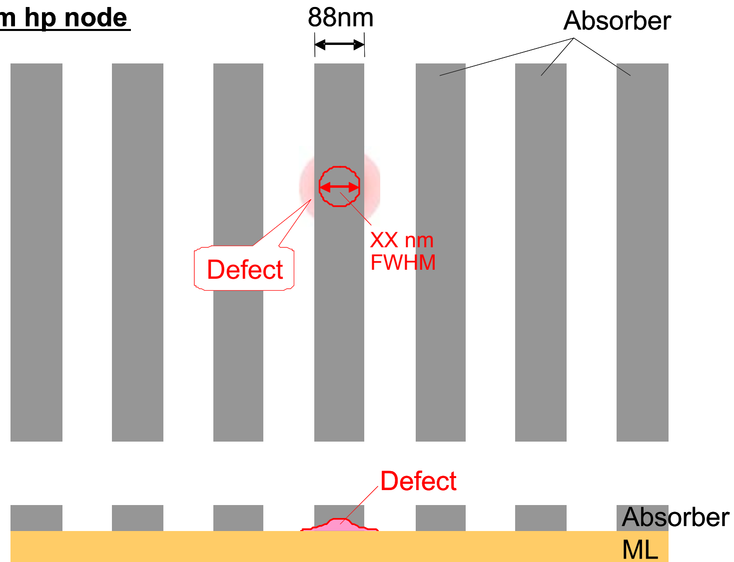
October, 2009

Outline

- Introduction and strawman alignment budget
- Background information on budget allocation for current systems
- Background information on budget allocation needed for 22nm hp node systems

Implementing Fiducial Marks to mitigate defects requires alignment capability for inspection and writer tools

Lasertech
22nm hp node



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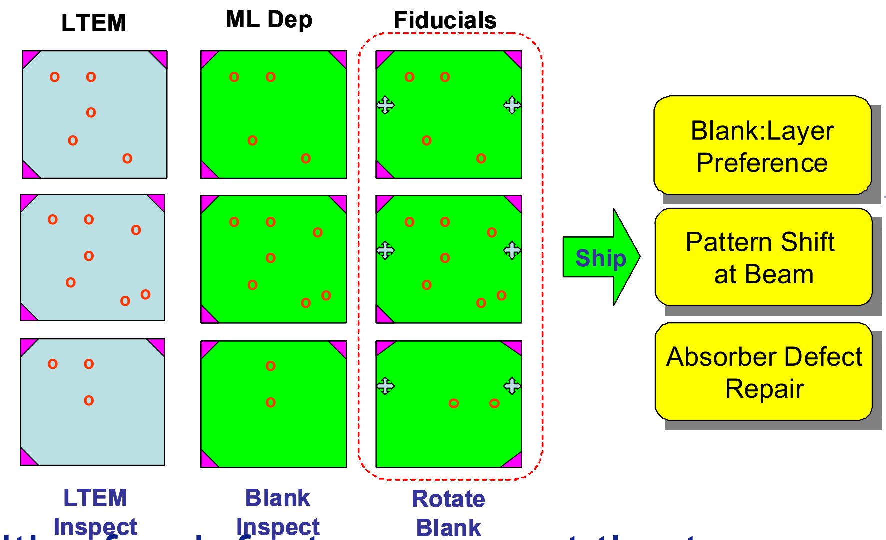

- Maximum defect size is the width of a defect as seen at the top of the multilayer (ML)
  - This defect width can be "hidden" under absorber
  - Goal is to "hide" ≤ 40nm defect
- Assume that the closest pattern to the defect is 88nm (22nm CD at wafer)
- Inspection and writing are done at the same temperature

The strawman alignment budget shows that significant improvements are needed in order to implement fiducial marks for 22nm features

Strawman Budget Estimates (units are in nm)	Current Capability		Needed Capability	
Defect Inspection tool contribution	± 702.5		± 14.1	
Alignment Accuracy to Fiducial Mark		± 200.0		± 4.6
Alignment Repeatability to Fiducial Mark		included above		± 2.0
Measurement Accuracy to center of Defect		± 500.0		± 5.0
Defect Size Measurement Accuracy		± 2.5		± 2.5
E-Beam Writer Contribution	± 15.3		± 8.6	
Alignment Accuracy to Fiducial Mark		± 10.0		± 4.6
Alignment Repeatability to Fiducial Mark		± 0.8		± .8
Image Placement Accuracy		± 4.0		± 2.7
Image Placement Repeatability		± 0.5		± 0.5
Reticle mounting differences between writer and inspection	± 1.1		± 0.6	
Estimated maximum defect size which can be covered by a 88nm absorber line	(1,349.8)		41.5	

Sub-Budget sum | Ref. Avail. | Estimate

Note that this budget just gets to 40nm defect coverage

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Budget allocation for a typical defect inspection tool comes from published data

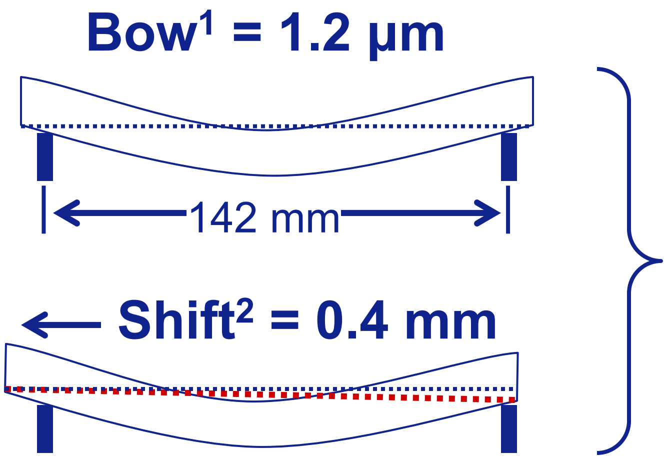
- Defect Inspection Tool Alignment Accuracy (±200 nm)
  - Pei-Yang (Fiducial Mark Task Force meeting – July 2009 and BACUS 2009) ~200nm
- Alignment repeatability
  - Already included in the alignment accuracy allocation
- Measurement Accuracy to center of defect (±500 nm)
  - Lasertec M1350 stage accuracy estimate from Pei-Yang (BACUS 2009)
- Defect Size Measurement Accuracy (±2.5 nm)
  - Particle size and bin #s from Lasertec M1350 output: ~±2.5nm @54nm particle size

Bin #	Particle Size (nm)
7	70
5	59
4	54

Budget allocation for the E-beam writer comes from various data sources

- E-beam writer alignment accuracy (±10 nm)
  Correspondence from S. Yoshitake of NuFlare
- Alignment repeatability (±0.8nm)
  - Direct write E-beam paper: Proc. of SPIE Vol. 6792 679211-1
    - Repeatability of best mark type given in paper
- Image placement error (±4.0 nm)
  - Based on best registration data from ASML EUV masks
  - Double patterning drives this in mask fabrication to be even smaller
- Image placement repeatability (±0.5 nm)
  - Estimated value. Should be smaller than 1nm otherwise E-beam stitching errors would dominate

Mounting differences are estimated from current substrate performance



2 different mountings:
Defect Inspection tool
E-beam writer

Analyze tilts based on shift of reticle on mounts by 0.4mm
Calculate "IPD" error (0.3 nm)

Add effect of backside non-flatness of 100nm which gives and "IPD" error of (0.8 nm)

[1]SEMI P-37 Guidance

[2]Published pattern centrality; full error is assume for the shift

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Budget allocation for 22nm defect inspection tool is based on data from other systems

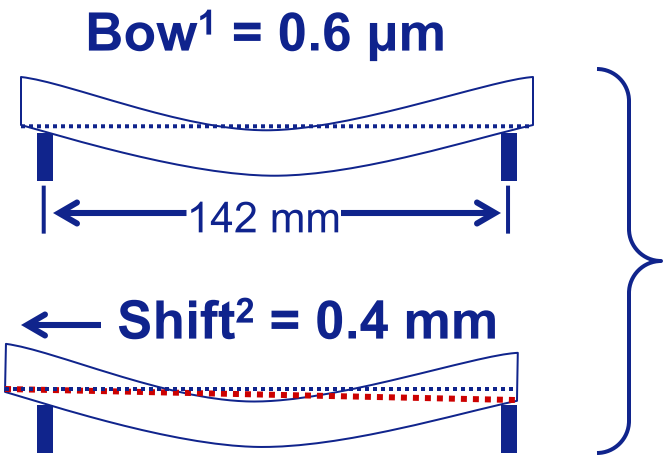
- Defect Inspection Alignment Accuracy (±4.6 nm)
  - Same as today's best-of-breed E-beam Writer
- Alignment repeatability (±2.0 nm)
  - Same as today's best-of-breed E-beam Writer
- Measurement Accuracy to center of defect (±5 nm)
  - Estimated based on using stage interferometers and spatial calibration of detectors (exposure tools are at < 1nm)
- Defect Size Measurement Accuracy (±2.5nm)
  - Particle size and bin #s from Lasertec M1350 output: ~±2.5nm @54nm particle size

Bin #	Particle Size (nm)
7	70
5	59
4	54

Budget allocation for 22nm e-beam writer tools are derived from current best-of-breed

- E-beam writer alignment accuracy (±4.6 nm)
  - Proc. of SPIE Vol. 6792 679211-1
  - Converted the two layer data to one layer alignment
- Alignment repeatability (±0.8 nm)
  - Direct write E-beam paper: Proc. of SPIE Vol. 6792 679211-1
  - Repeatability of best mark type given in paper
- Image placement error (±2.7 nm)
  - NuFlare paper: S. Yoshitake, EMLC 2009
- Image placement repeatability (±0.5 nm)
  - Estimated value. Should be smaller than 1nm otherwise E-beam stitching errors would dominate

Mounting differences are estimated from targeted substrate performance



2 different mountings:
Defect Inspection tool
E-beam writer

Analyze tilts based on shift of reticle on mounts by 0.4mm Calculate "IPD" error (0.15 nm)

Add effect of backside non-flatness of 60nm which gives and "IPD" error of (0.48 nm)

[1]SEMI P-37 Guidance

[2]Published pattern centrality; full error is assume for the shift