#041

At-wavelength Defect Inspection of EUVL Mask Blanks

Anton Barty[1], Yanwei Liu[2], Rick Levesque[1], Jay Ayers[1], Eric Gullikson[2] and Phil Seidel[3]

[1] Lawrence Livermore National Laboratory, P.O.Box 808, Livermore, CA, 94550
[2] Lawrence Berkeley National Laboratory, 1 Cyclotron Rd, Berkeley, CA, 94720
[3] International SEMATECH, 2706 Montopolis Drive, Austin, TX, 78741

Overview

Technical Objectives

- Construction of a 2nd generation actinic EUV mask blank inspection and AIM defect review tool
- Conduct benchmarking experiments comparing visible inspection tools at ISMTN Albany and the Sematech at-wavelength mask blank inspection tool located at the ALS
- Support AIM mode imaging of EUVL masks
- Provide benchmarking capability for the commercial AIM tool to be installed at ISMTN

Accomplishments to date

- Completed initial design review - upgrade path selected
- Conceptual design of mechanical components complete
- Vendor engaged to build end-station, ready to start
- Delivery of end-station scheduled for Q2, 2004
- Experimental plan of action formulated - available from ISMT

1

Actinic inspection must determine whether there are false negatives in non-actinic inspection techniques

Non-actinic inspection result	Printable defect: Defect	Printable defect: No defect
Defect	Inspection is correct (desired result)	False positive (mask is actually OK)
No defect	False Negative (defect exists but is not found)	Inspection is correct (desired result)

Accurate discrimination in non-actinic inspection is essential:

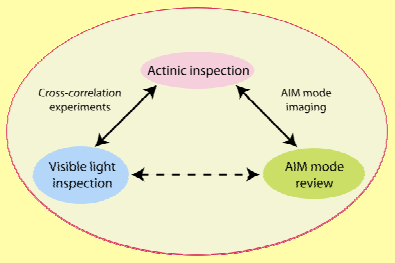
- False negatives are discovered during or after patterning (at high cost)
- False positives decrease yield by rejecting good masks, increasing mask cost
- A defect review tool (AIM microscope) could help discriminate false positives (at the added cost of defect review)

Need a fast EUV mask scanner

- A large area of low-defect mask must be scanned to gather adequate statistics

2

Project goal is to determine whether actinic mask blank inspection is required for EUVL



Correlate results of actinic inspection with visible light scattering tools:

- Top-level strategy is to measure the same samples in both inspection tools
- Check whether the same defects are reliably captured by both systems
- AIM mode review determines whether the differences are significant

3

Combined LLNL and LBNL team has been assembled

Henry Chapman, Don Sweeney, Rick Levesque, Anton Barty, Jay Ayers

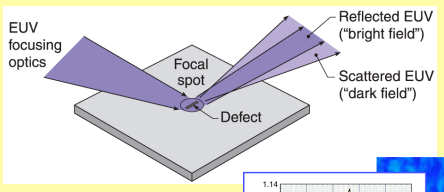
Paul Barale, Greg Denbeaux, Eric Gullikson, Yanwei Liu

Also: Jeff Bokor, Seongtae Jong, Moonsuk Yi
Paul Denham, Seno Rekawa, Phil Batson
Ken Goldberg, Patrick Naulleau

At International SEMATECH:
Obert Wood, Phil Seidel, Kurt Kimmell

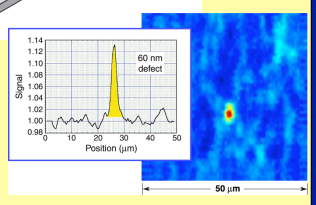
4

1st generation actinic Mask Blank Inspection system at the ALS in Berkeley



Limitations:

- 8hr/cm² scan speed
- 60nm PSL sensitivity
- No imaging mode for defect review



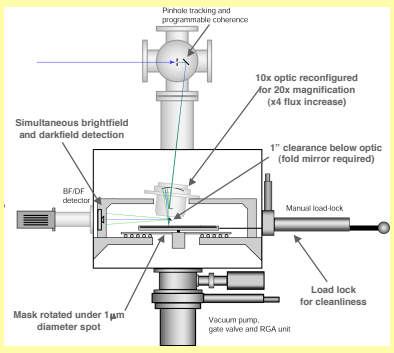
5

Design review of possible upgrade paths led to a hybrid scanning/zone plate microscope system

- Upgrade paths considered
  - High Speed Scanning mode:
    - Using the existing Kirkpatrick-Baez optics and performing system upgrades
    - Zone plate dark-field imaging microscope
    - Scanning system using 10x Schwarzschild optics
  - Aerial Image Microscope mode:
    - Zone plate scanning microscope
    - Scanning system using 10x Schwarzschild optics
  - Final choices
    - 10x based scanning system for inspection mode
    - Zone plate microscope will be used for Aerial Image Microscope mode using 10x as a condenser
- Key specifications and performance requirements
  - Clean handling is essential for accurate cross-registration of defects
  - < 1defect/cm² added defect level target
  - 2 cm²/hr scan speed targeted
  - AIM mode specifications compatible with imaging MET masks

6

Scanning mode uses simultaneous brightfield and darkfield detection to detect defects



Key parameters

Wavelength: 13.5nm

Angle of incidence: 6 degrees

Scan speed: ≈2cm²/hr

Spot size: ≈1μm Ø

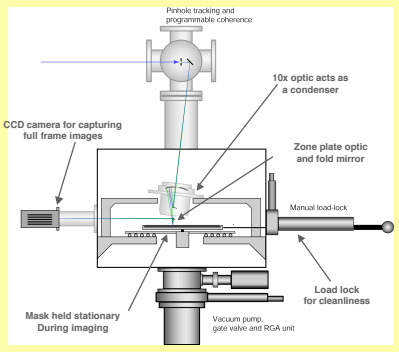
Added defects: < 1 per cm²

Defect location: < 10μm

Sensitivity: 50nm

7

AIM mode uses a zone plate microscope for defect imaging



Key parameters

Wavelength: 13.5nm

Angle of incidence: 6 degrees

NA to mask: 0.0625 NA (same as stepper)

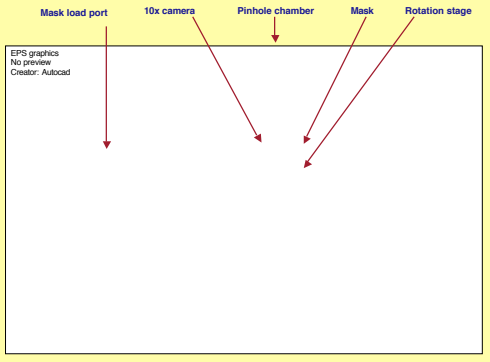
Exposure time: ≈15sec

Imaged area: ≈10μm Ø

Time to change to imaging mode: <30 min

8

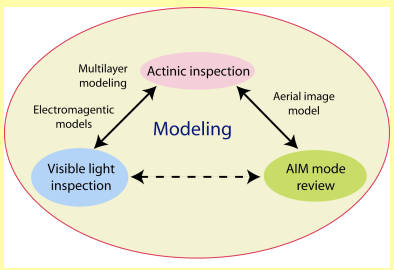
Mechanical concept design advanced - ready to build



Status: Vendor engaged and ready to start building.
Due to be installed by June 2004.

9

Multilayer modeling can be integrated to facilitate advanced learning on defect inspection and printability.

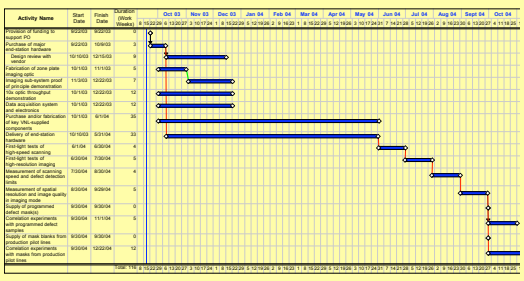


Modeling closes the loop on inspection learning by comparing predicted and measured aerial images :

- Does theory match experiment??
- Do models of EUV mask defects behaviour match observed printability

10

Delivery in Q2, 2004
Experiments in Q3-4 2004



11

Summary

- Unique mask inspection facility is being developed with ISMT support:
  - Will be the only high-speed at-wavelength mask blank inspection system in the world for benchmarking of high-speed visible-light inspection tools
  - Will provide early AIM benchmarking capability ahead of commercial tool availability (but is not being developed as competition for commercial AIM tools)
  - Compatible with masks printed in the adjacent MET exposure facility, enabling side-by-side AIM imaging and MET printing of the same mask
- Mechanical design work is in progress, and a clear experimental plan formulated
  - Conceptual design complete
  - Vendors engaged, ready to build
  - Plan to scan both programmed and native defect samples on mask blanks
  - Anticipate commencing delivery in Q2 2003
  - Cross-correlation experiments in Q3-Q4, 2004.

12

This work was performed under the auspices of the US Department of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48. Funding was provided by the Extreme Ultraviolet Limited Liability Corporation under a Cooperative Research and Development Agreement. The authors acknowledge funding from International SEMATECH under project Lith-343.