EUV Defect Repair Strategy

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Agenda

1. Blank and Mask Defects
2. Repair Strategy
3. AIMS EUV Status
4. Summary

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1 Blank and Mask Defects

2 Repair Strategy

3 AIMS EUV Status

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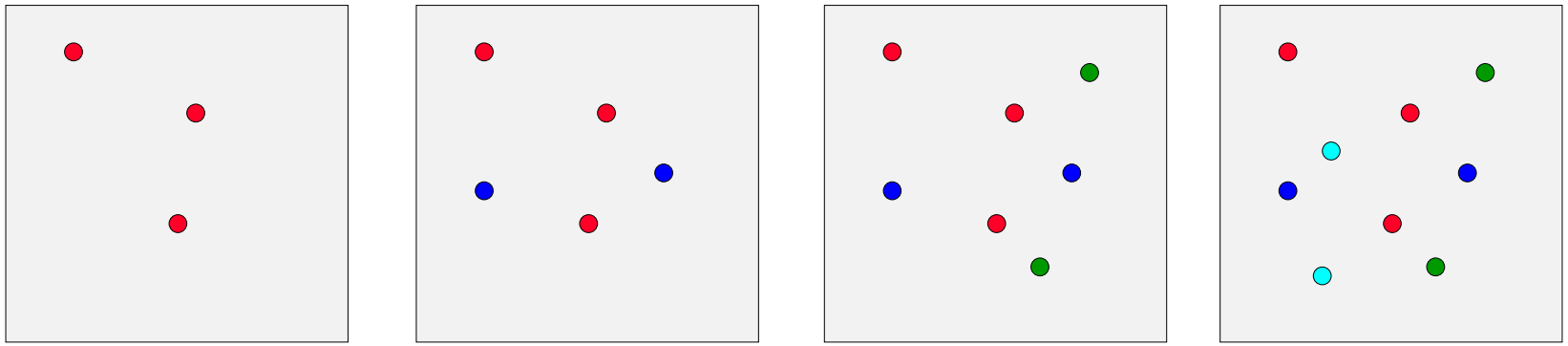
“Defect Flow”

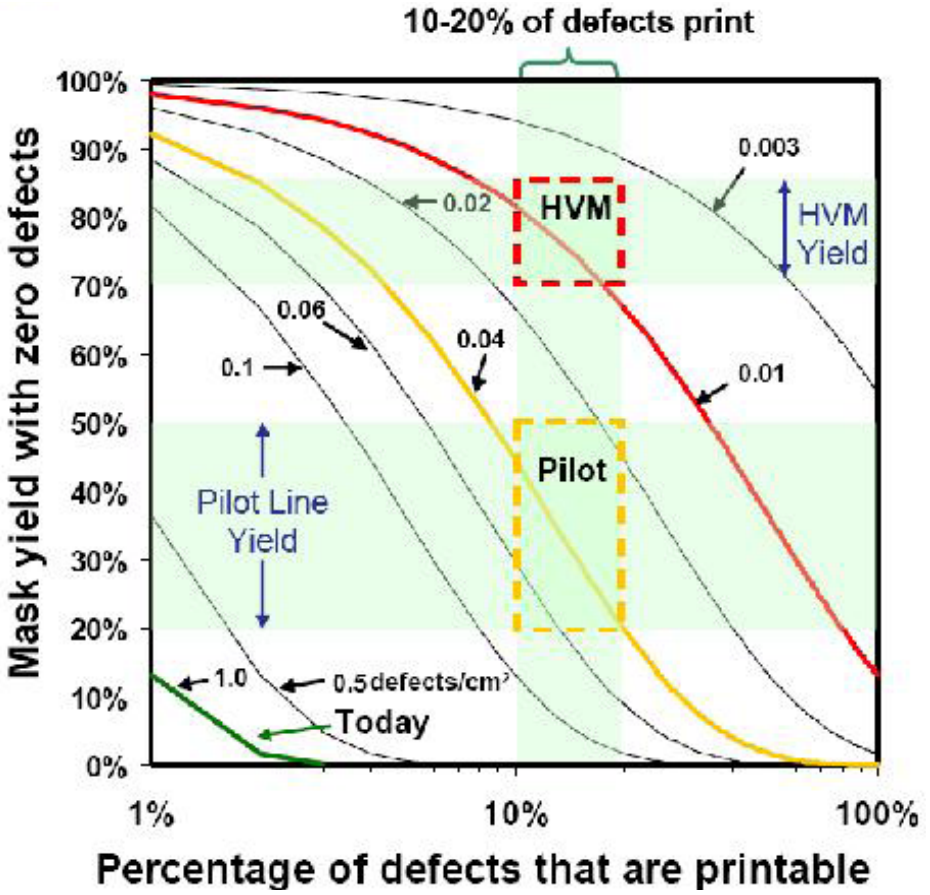


Substrate Polishing | ML Deposition | Mask Patterning | Transport/Usage in Fab

- Each manufacturing and handling step potentially adds defects (particle and/or pattern defects)
- Goal is to design a manufacturing flow that mitigates defects as much as possible or repairs defects that have been added in the preceding steps
- **Target is zero printable defects**

Blank Defect Level

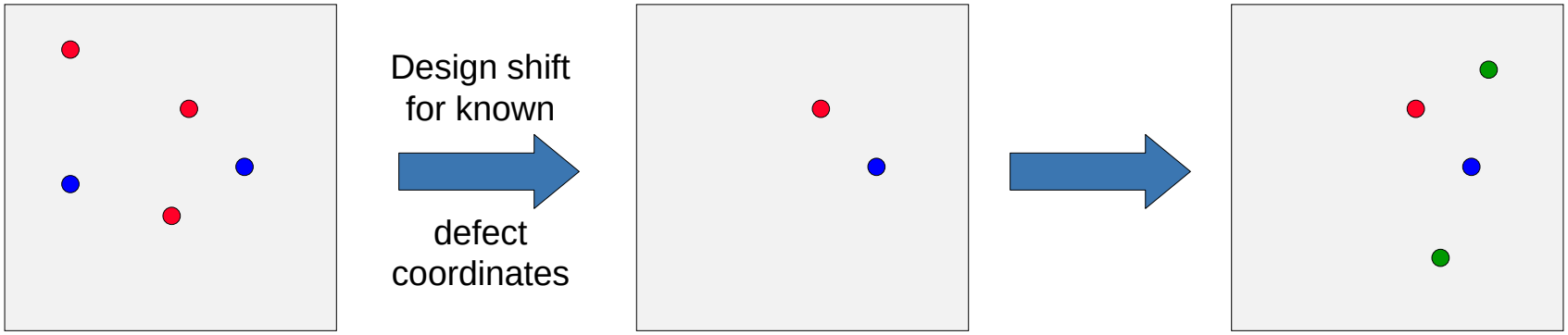
- Large gap for “zero defect” blanks → low yield for production
- EUV blanks will still have defects when high volume manufacturing starts
- Challenge: take this fact into consideration for mask manufacturing



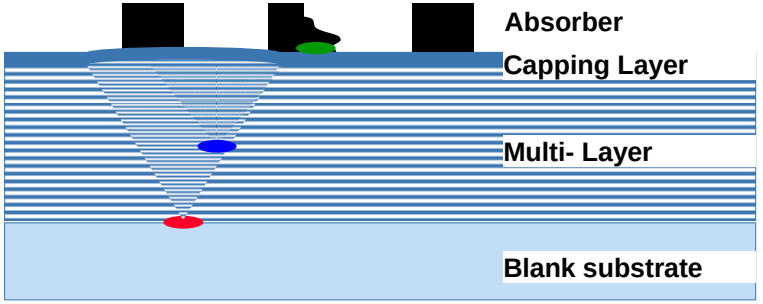
Source: SEMATECH

Mask Manufacturing Flow

- Blank inspection tools need to deliver **exact** locations and sizes of defects
- Pattern will be placed in a way to hide majority of remaining defects
- Followed by standard mask manufacturing process



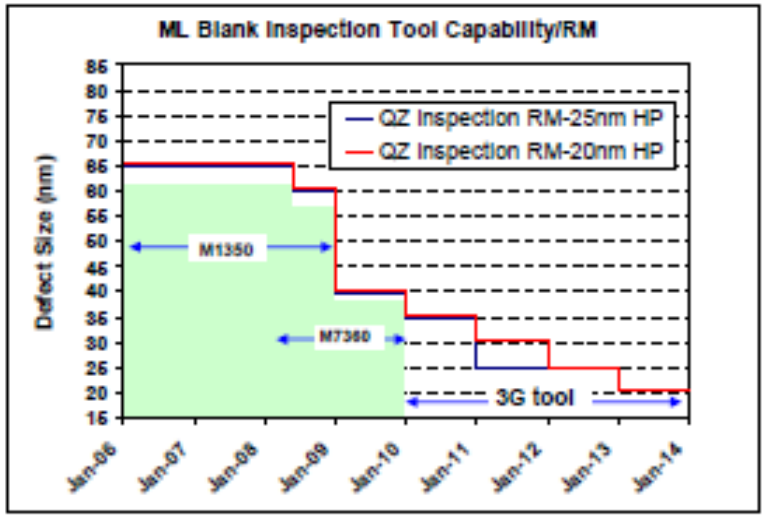
- Flow will results in mixture of absorber defects and ML defects



Find and Review Defects

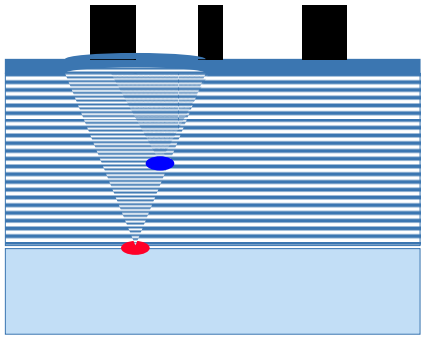
- There are infrastructure gaps to find and review defects with EUV light
- Joint industry effort to close the gaps led by SEMATECH
- One of the projects has started: **AIMS™ EUV development to close defect actinic review gap**

Find defects



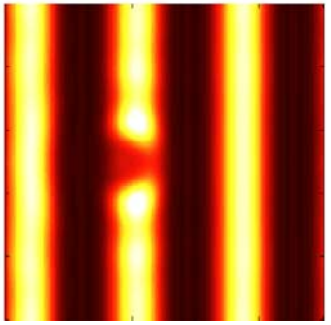
Source: Andy Ma (EUVL 2010 Kobe)

Review defects



Blank defects convert Into phase defects

Phase defects cause printing defects although patterning was perfect



Aerial Image

Solely actinic 13 nm mask qualifications by AIMS™ EUV can predict printing behavior of the defects in EUV mask manufacturing environment

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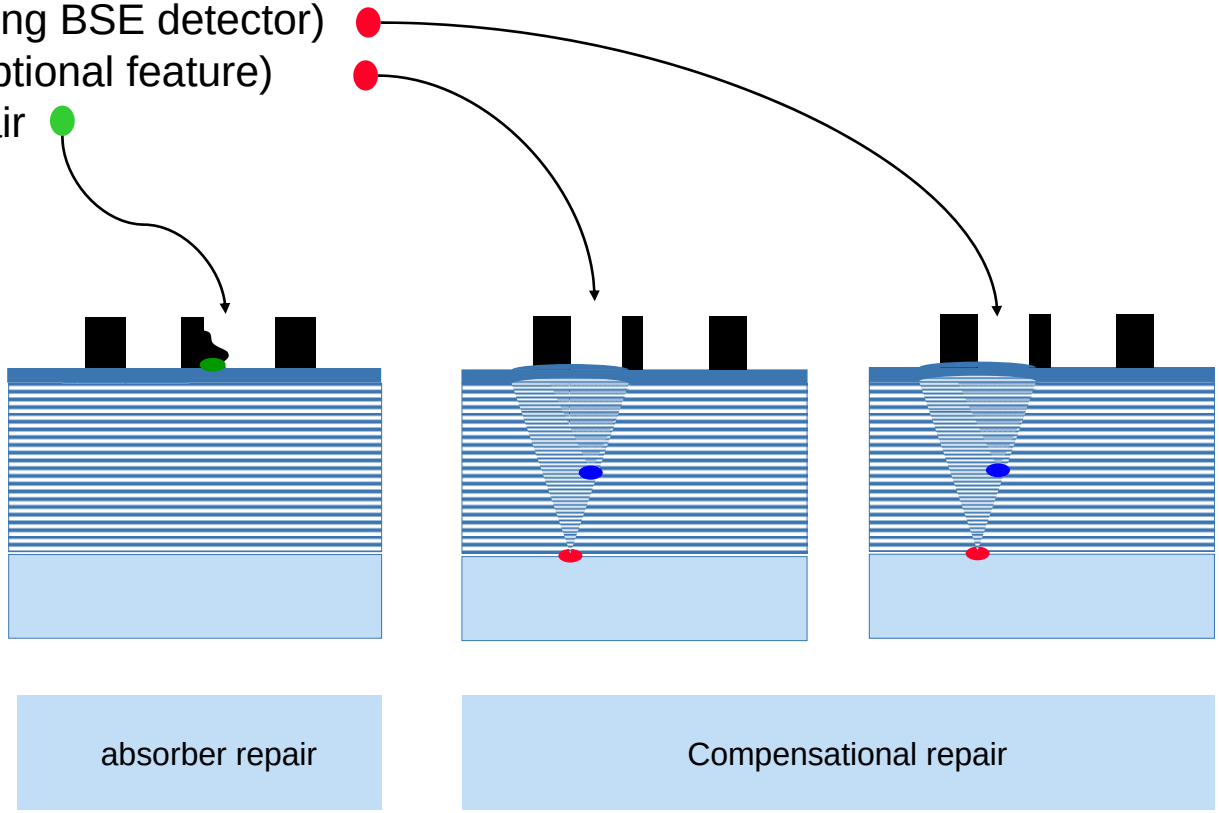
EUV absorber and ML defect repair strategy

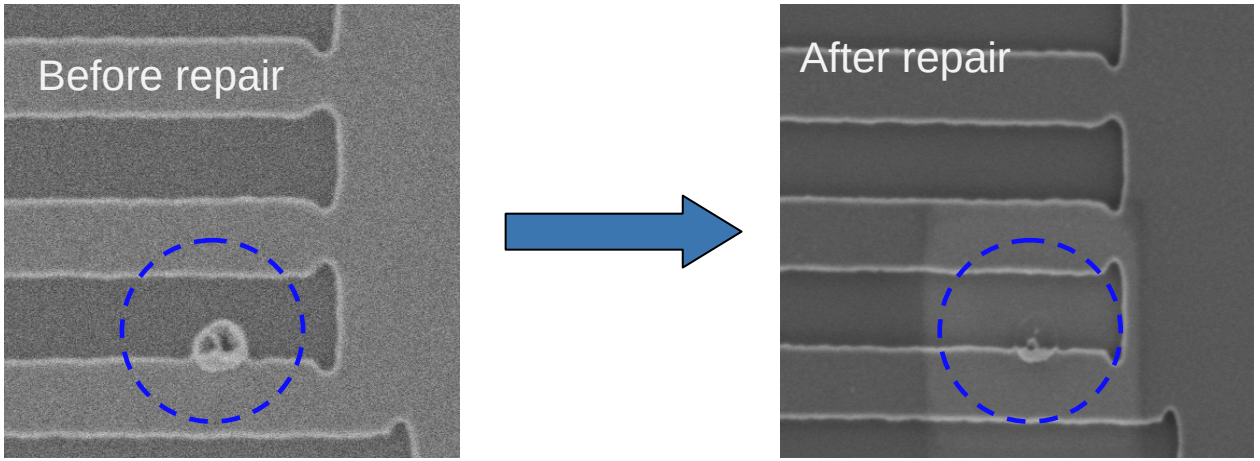
The MeRiT® can locate the exact position of defects with a surface topography

- With the ebeam (including BSE detector)
- With the in-situ AFM (optional feature)
- Classical absorber repair

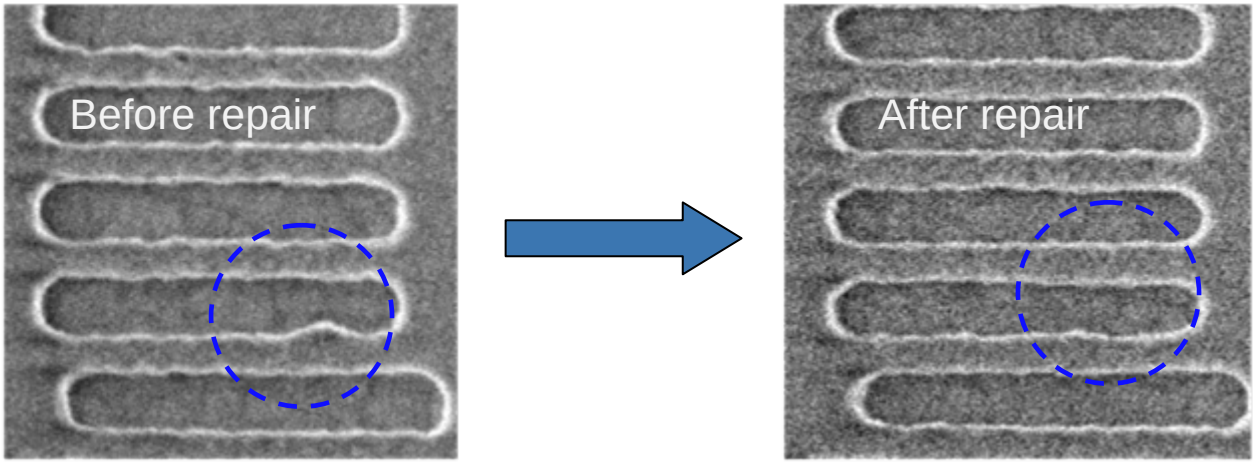


Classical Absorber Repair with MeRiT® HR

SEM image
EUV Mask:



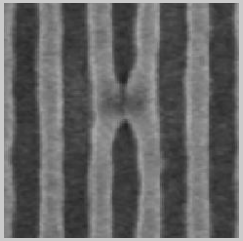
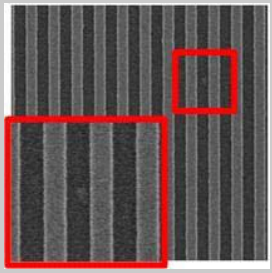
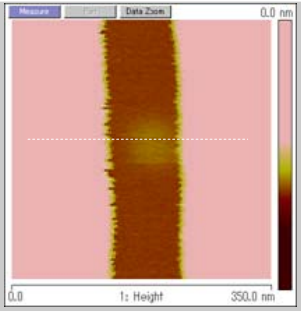
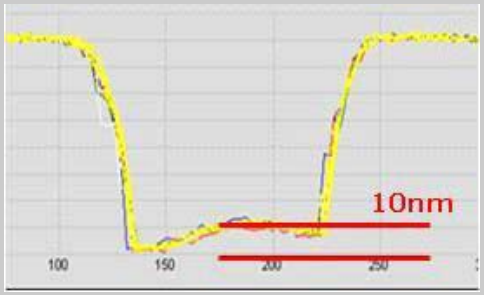
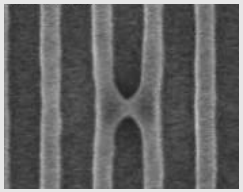
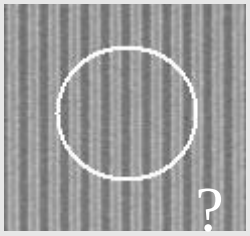
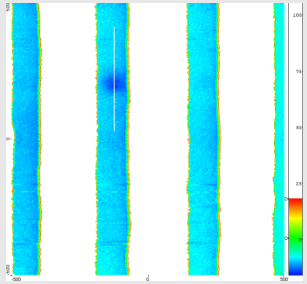
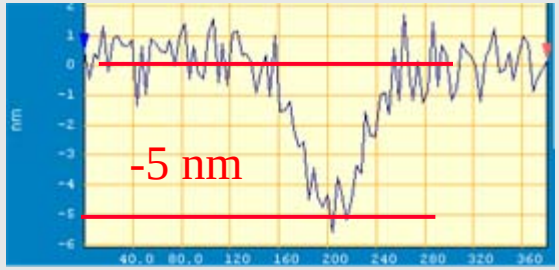
SEM image
Wafer print:



→ **Defect was repaired successfully**

EUV Defects and Compensational Repair

- EUV-specific multilayer defects are often SEM-invisible → use AFM
- Printing defects can be +/- 3 nm shallow: Compensational repairs performed

Multilayer defect type	Wafer print	Mask SEM	Mask AFM	AFM cross-section
„Bump“				
„Pit“				

Defect Repair with MeRiT® HR

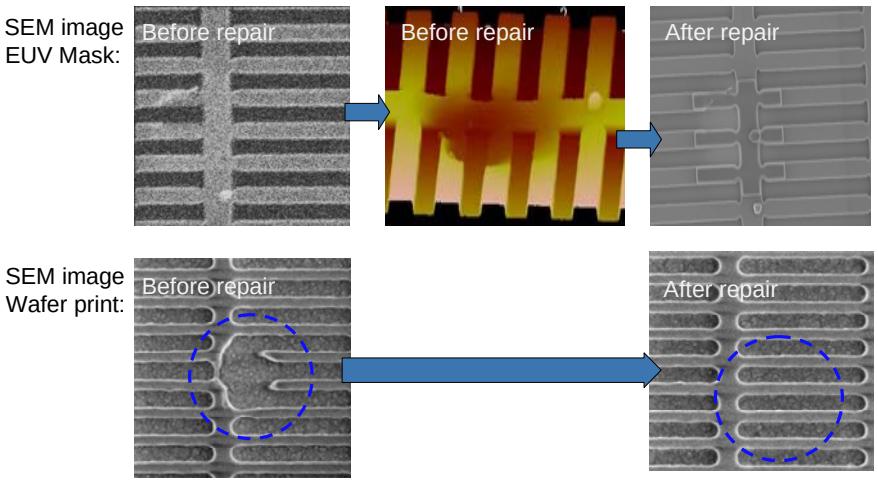
Removing pattern defects.

- EUV mask pattern repair possible already now with MeRiT® HR 32
- Further refinement with future platforms

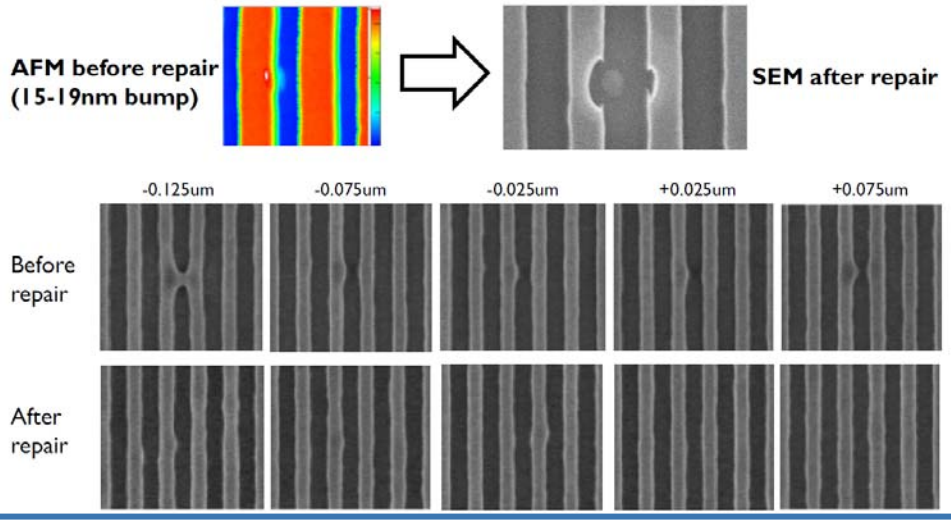
Compensating effect of blank defects

- Mitigation of ML defects by compensational repair shown
- Making use of in-situ AFM feature of MeRiT® HR 32

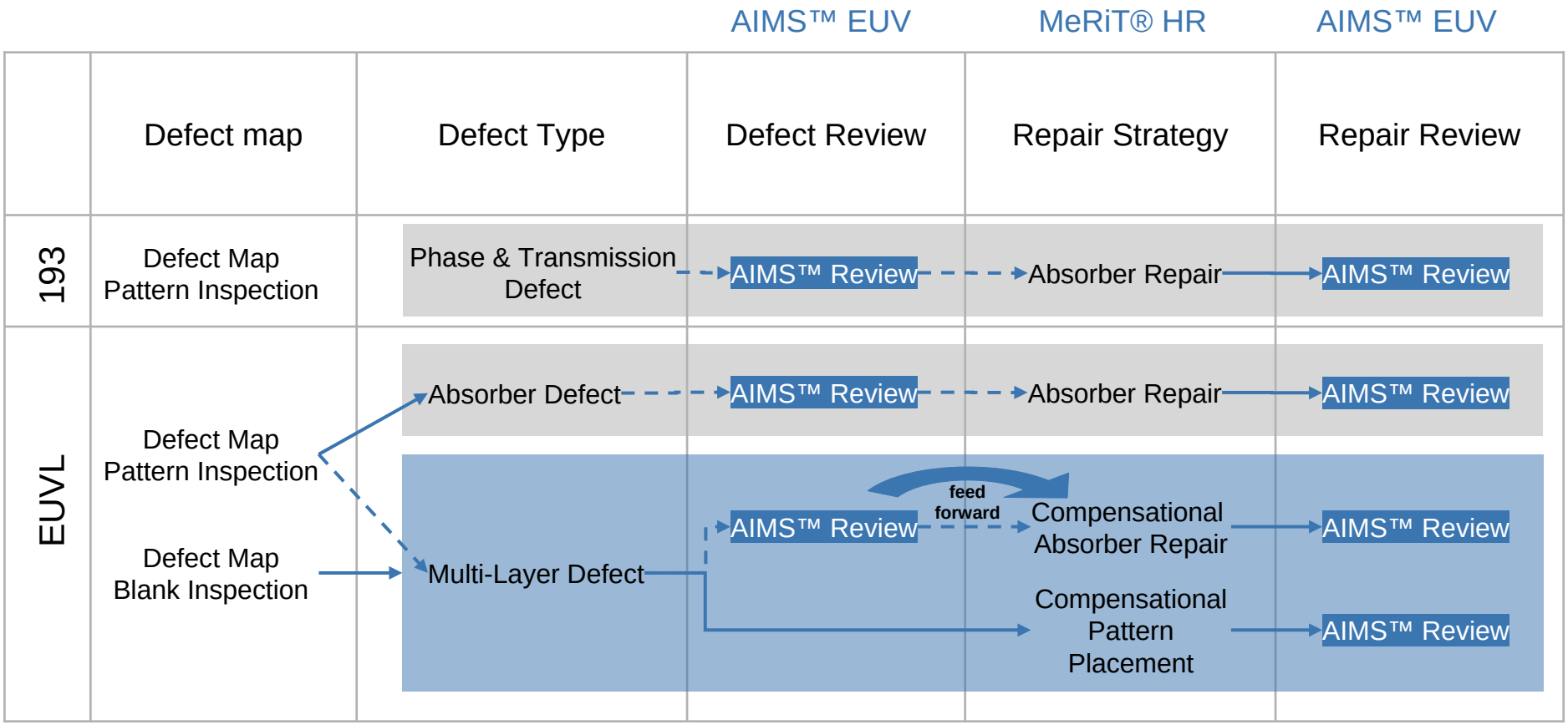
Removing pattern defects



compensating ML defects



Repair Strategy using AIMS™ and MeRiT®



- AIMS™EUV review needed for both defect types and repair strategies
- Number of processes requiring review increases in EUV compared to 193 increased

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AIMS™ EUV Project started

Industry-Leading Semiconductor Companies Join SEMATECH's EUVL Mask Infrastructure (EMI) Partnership at UAlbany NanoCollege

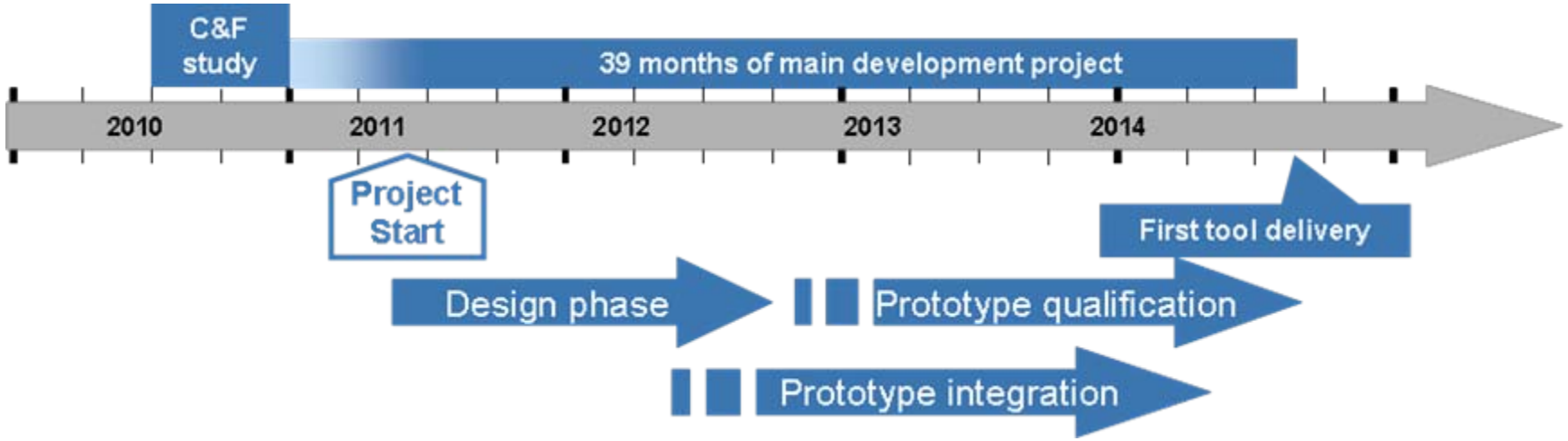
Carl Zeiss begins main development of AIMS™ System to target mask defects for 22 nm half-pitch node and below

ALBANY, N.Y. and JENA, GERMANY – July 12, 2011 – SEMATECH announced today that Intel, GLOBALFOUNDRIES, Samsung Electronics Co., Ltd., and TSMC have joined SEMATECH's EMI Partnership to develop critical metrology tools for reviewing defects in advanced masks needed for extreme ultraviolet lithography (EUVL). In collaboration with SEMATECH, these leading semiconductor companies are pursuing an ambitious metrology program to enable defect-free EUVL masks for high-volume manufacturing.

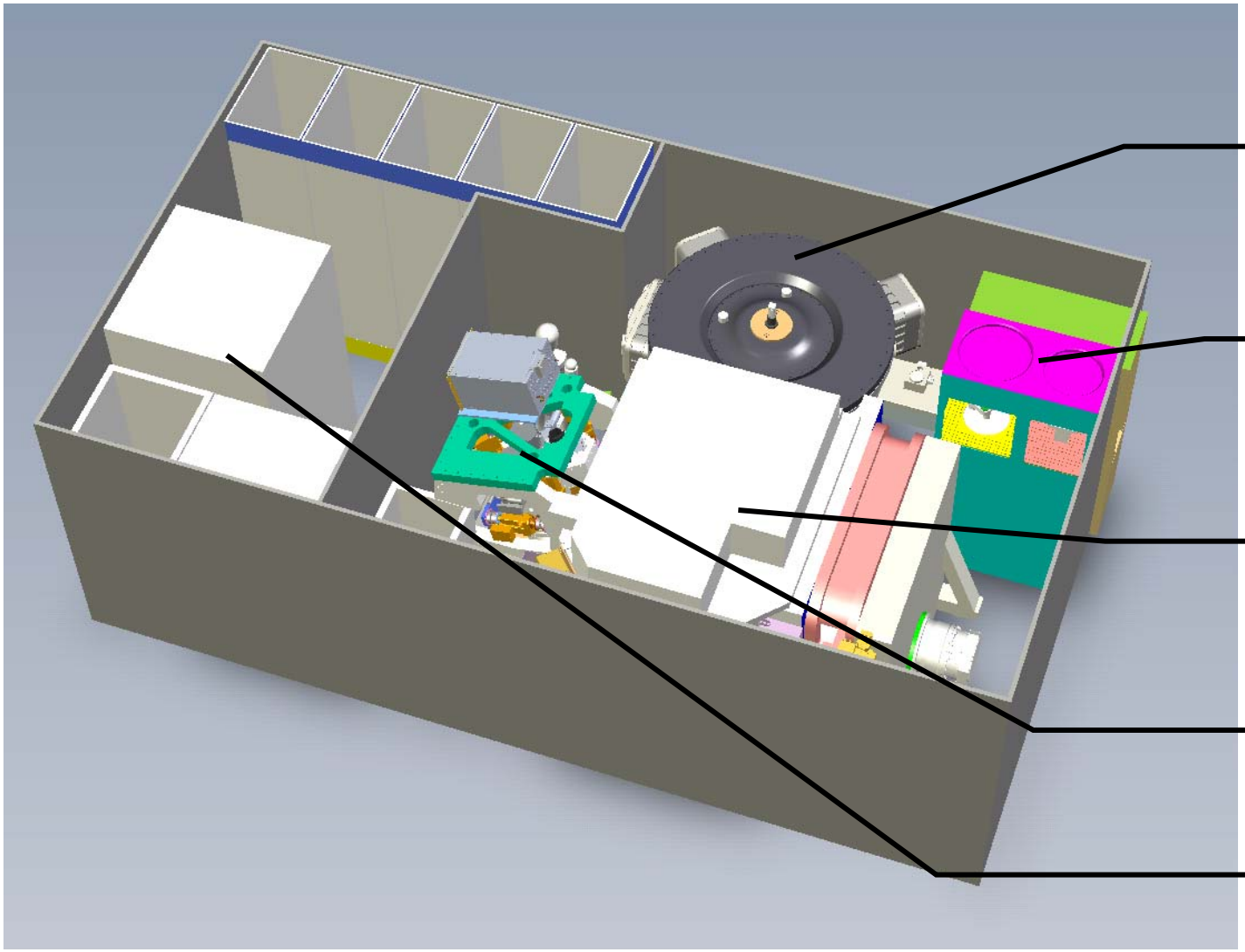
→ see also Session 3, Monday, 17. Oct., Michael Goldstein
"Update from the Sematech EUV Mask Infrastrutcure Initiative"

Defect Review with AIMS™ EUV

- Project started in June 2011
- 4 industrial partners
- Prototype ready by August 2014
- First customer tools ready by August 2014 then 1 tool every 4 months
- Currently project is within the design phase



AIMS™ EUV Design Phase: Preliminary Layout of the AIMS™EUV



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Essential to find and classify all defects

- Current blank and mask pattern inspection methods not sufficient
- Joint industry effort started to close gaps
- AIMS™ EUV needed for disposition or repair verification
- AIMS™ EUV project started and on track

Repair or mitigate defects

- Blank defect mitigation concepts existing but need to be proven in process flow
- Pattern defects can be repaired as for standard 193nm masks
- ML defects cannot be repaired as of today
- ML defect however can be compensated by compensational repair methods

Zeiss provides critical tools and solutions for EUV mask manufacturing

- Mask manufacturing tools will be ready in time for HVM

Acknowledgements

Defect studies and repair
- Tristan Bret, Thorsten Hofmann and the Zeiss SMS team in Rossdorf

AIMS™ EUV
- Sascha Perlitz and Markus Weiss and the Zeiss teams in Jena and Oberkochen
- Sematech and the members of the EMI Consortium for their great financial support

And thanks to you for your attention!

We make it visible.