PAUL SCHERRER INSTITUT

PSI

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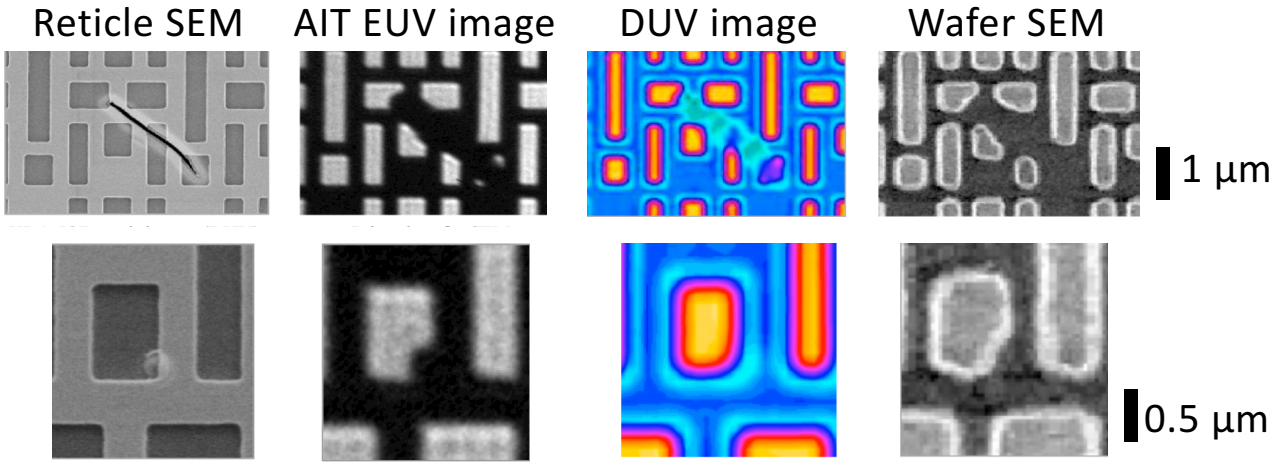
Lensless Actinic Inspection of EUV Reticles with RESCAN

EUVL symposium 2016

EUV reticle inspection for N7 and beyond

No actinic patterned reticle inspection platform available for industrial use

Actinic inspection is the most accurate approach for the detection and characterization of defect on EUV reticles.



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OUTLINE

Introduction to the RESCAN project

- Coherent diffraction
- Defect detection and localization

Experimental results

- Low resolution defect map
- Defect area image reconstruction

Rescan recent upgrades

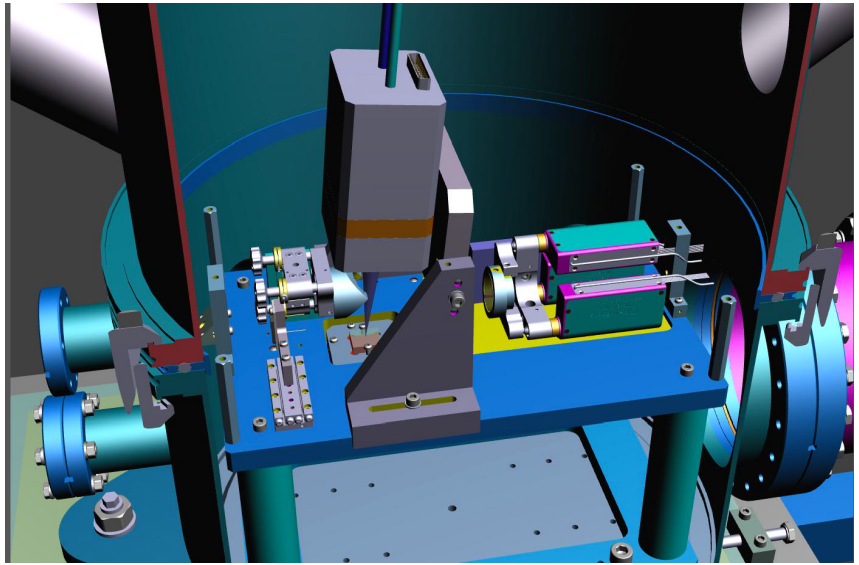
- A faster detector
- Dedicated beamline

What’s next

What is RESCAN?

An actinic inspection platform for the localization and classification of defects on EUV reticles @ SLS synchrotron.

Based on coherent scattering methods

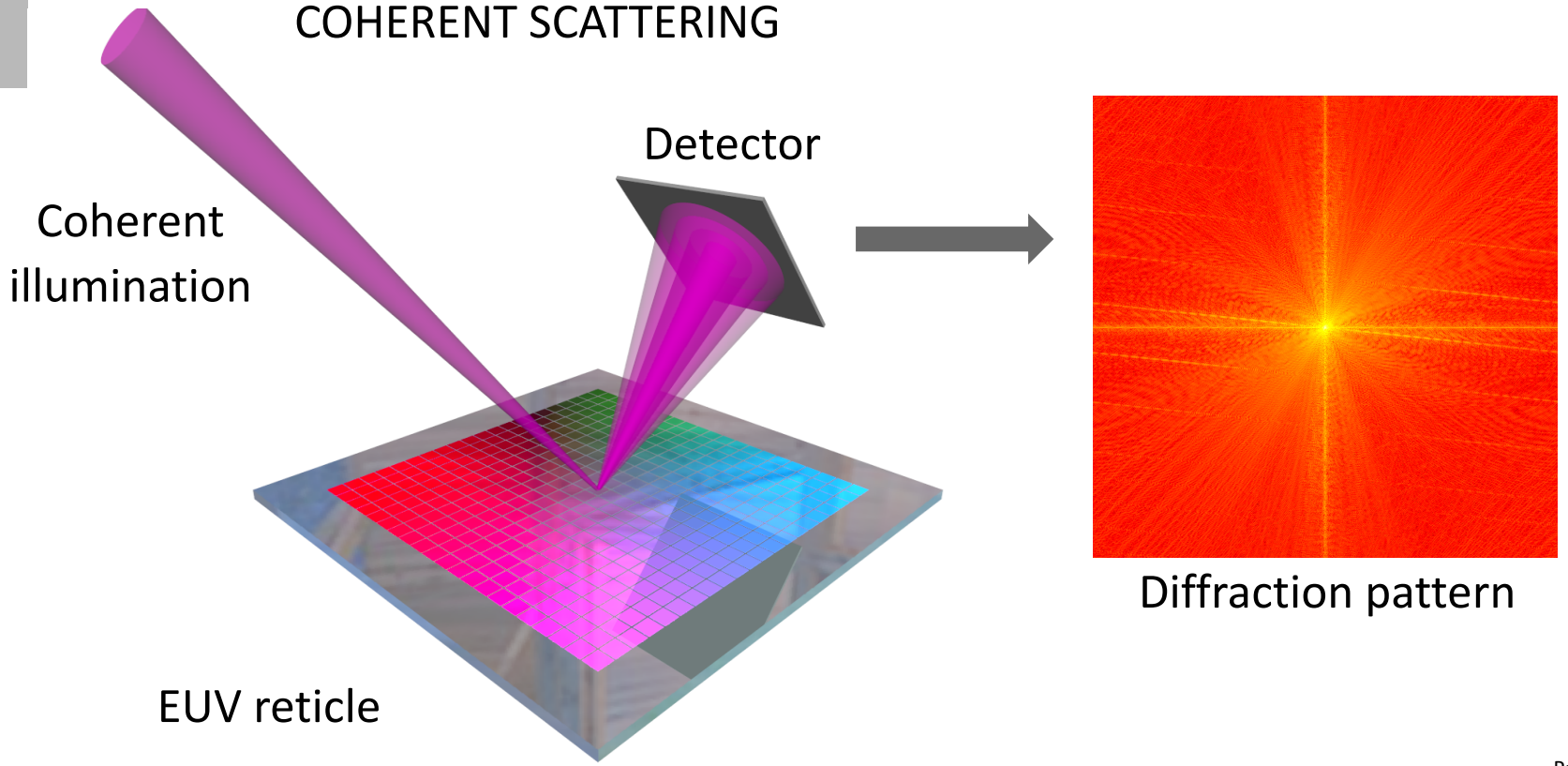


Target specifications:

Defect resolution: 10 nm

Inspection throughput: 7h/reticle

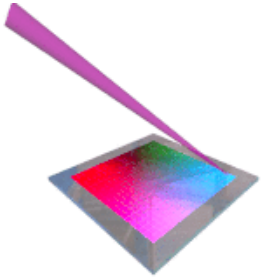
How does RESCAN work?



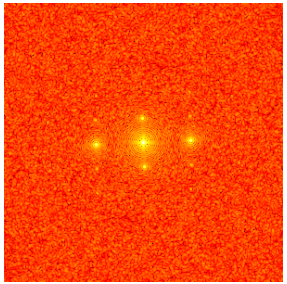
A TWO-STEP PROCESS

THE DEFECTS ARE DETECTED AND LOCALIZED IN TWO STEPS

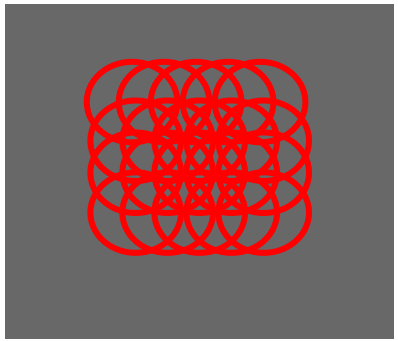
1. Fast mask scanning with variable-size probe



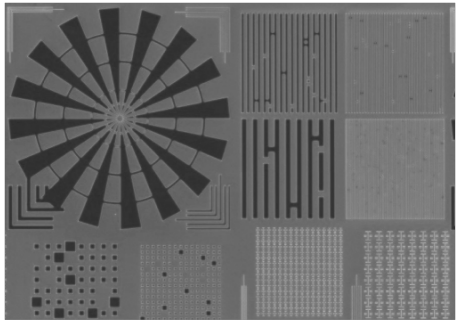
Diffraction pattern analysis



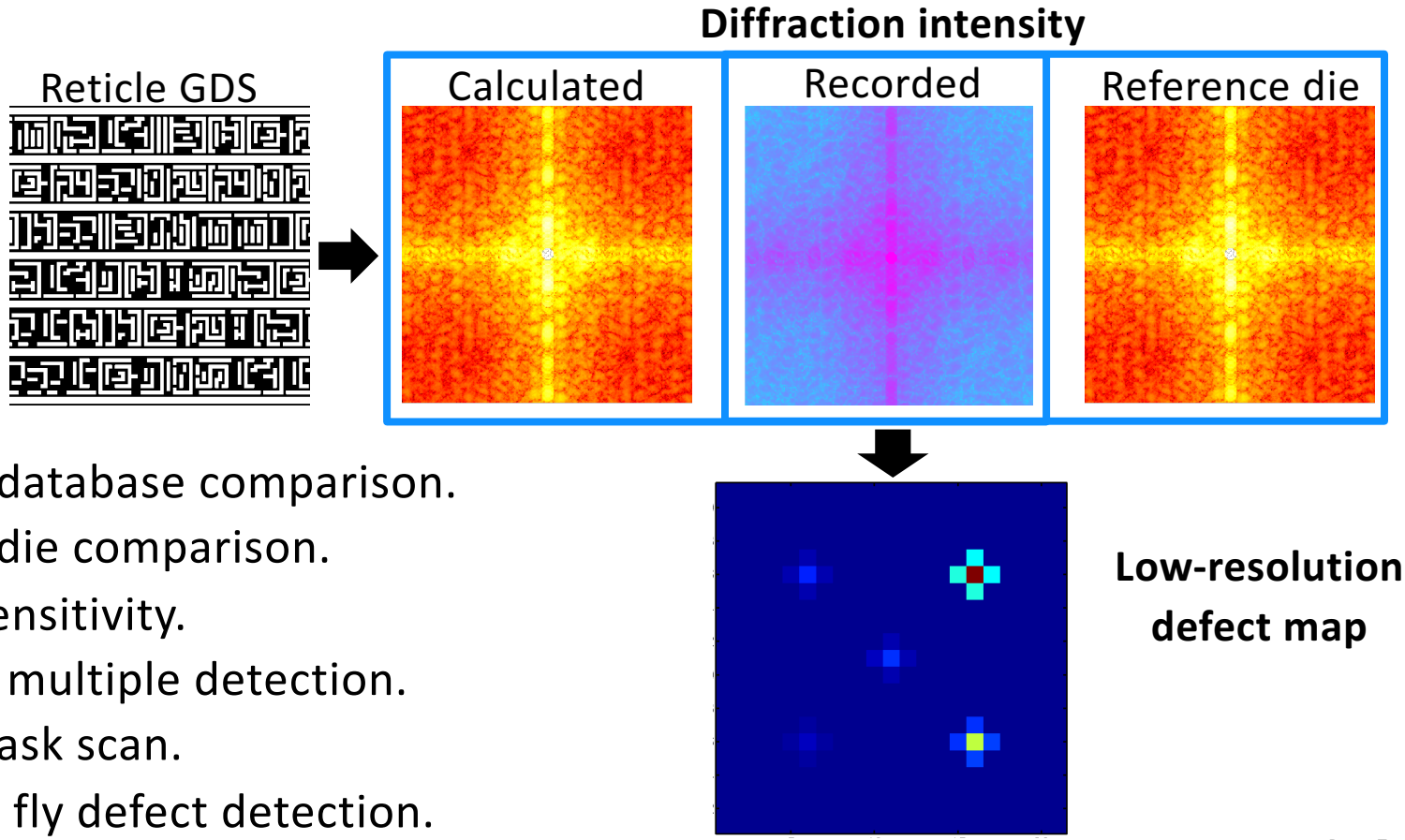
2. Aerial image reconstruction of defect zone



CDI reconstruction



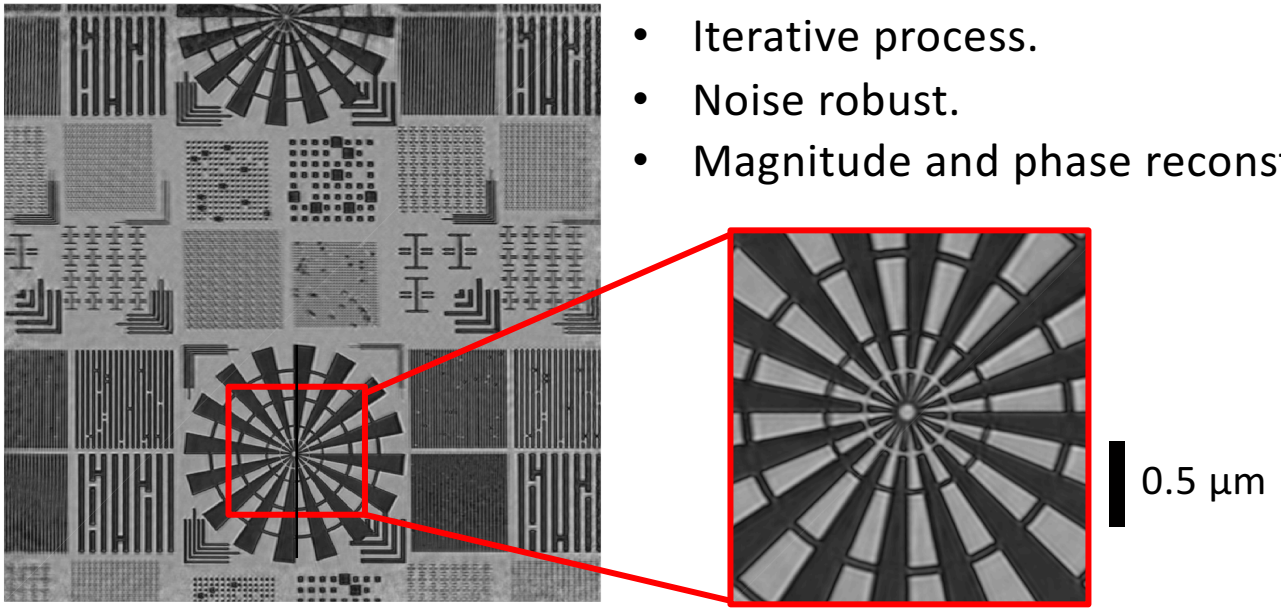
Defect identification



- Die to database comparison.
- Die to die comparison.
- High sensitivity.
- Defect multiple detection.
- Fast mask scan.
- On the fly defect detection.

Defect localization

Aerial image reconstruction with coherent diffraction imaging.

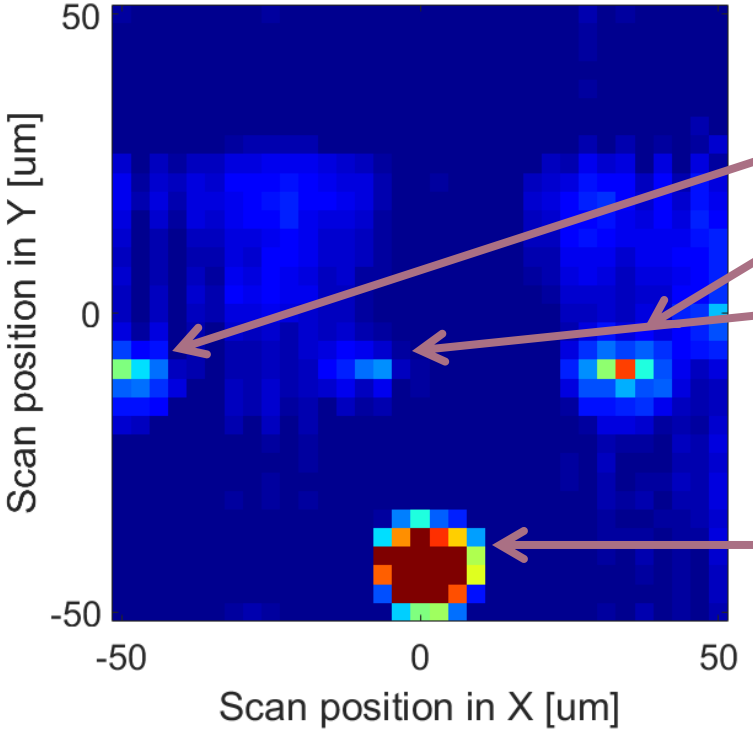


- Iterative process.
- Noise robust.
- Magnitude and phase reconstruction.

P-MA-06 ***Dr. P.Helfenstein*** Actinic EUV Mask Metrology with RESCAN using a monochromatic beam.

Defect detection– experimental results

25 nm hp grating



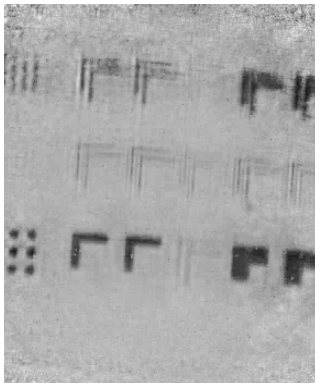
-40 x 2000 nm^2
CD error

+40 x 2000 nm^2
CD error

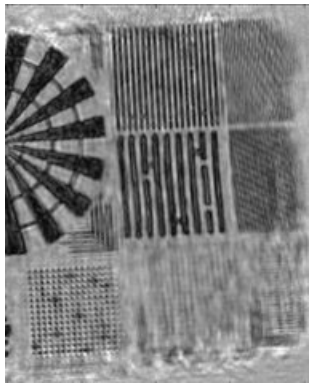
Large added particle

Defect localization – experimental results

RESCAN 1



October 2015

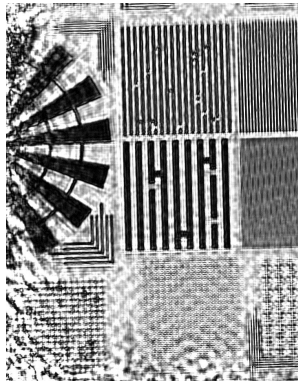


February 2016

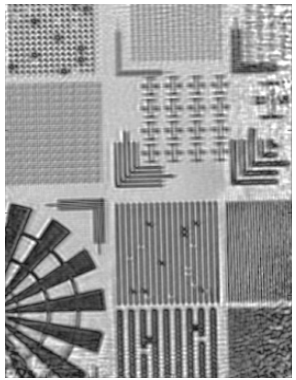
Reconstruction algorithm optimization

- Artifact reduction.
- Resolution enhancement.
- Field of view increase.

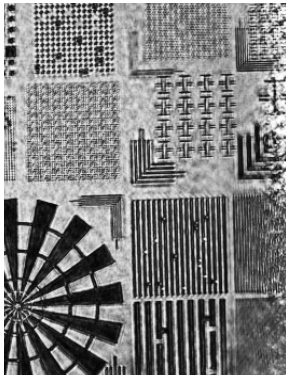
RESCAN 2



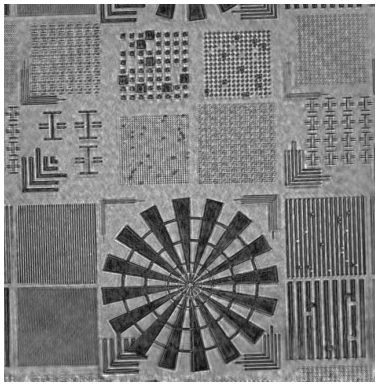
May 2016



June 2016



July 2016

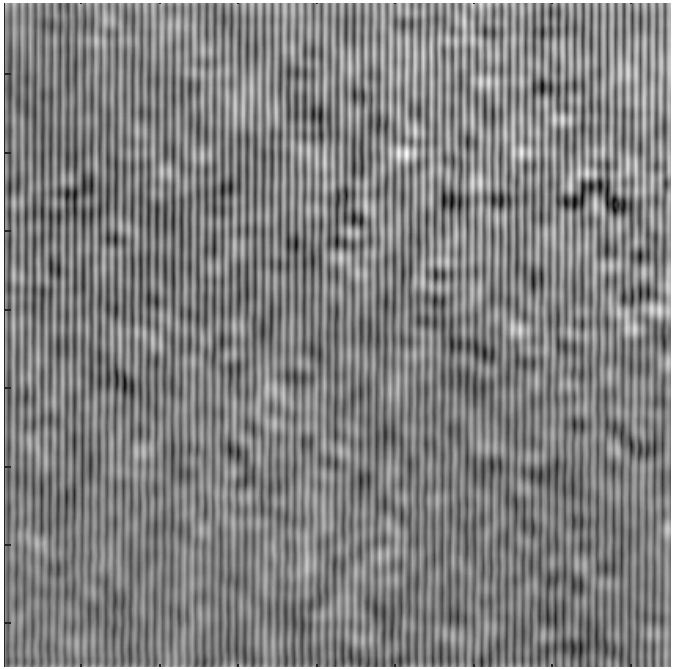


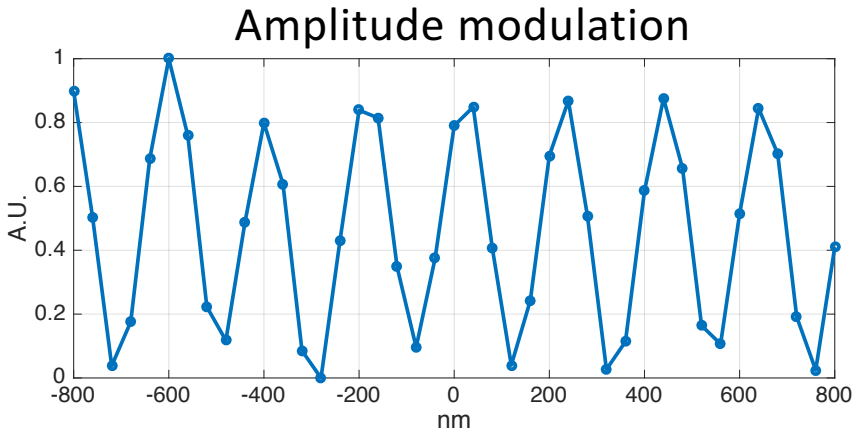
August 2016

Defect localization – experimental results

100 nm CD lines with programmed and native defects

Amplitude map

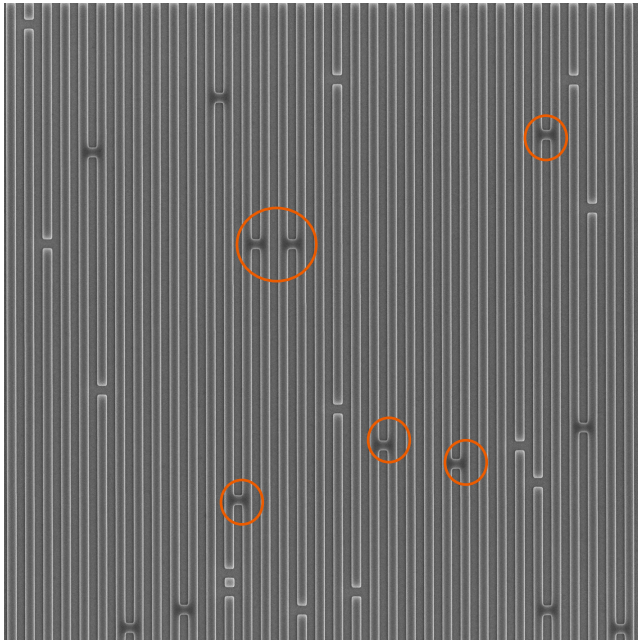




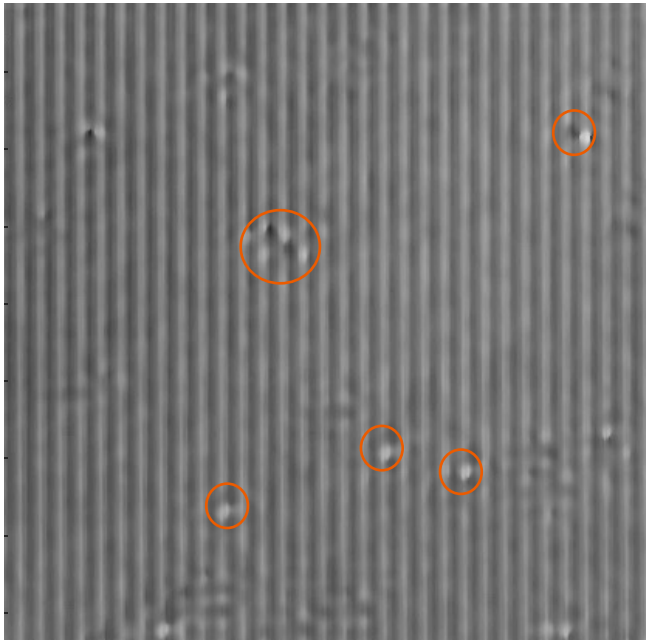
Defect localization – experimental results

Phase contrast is also useful for defect identification.

SEM image



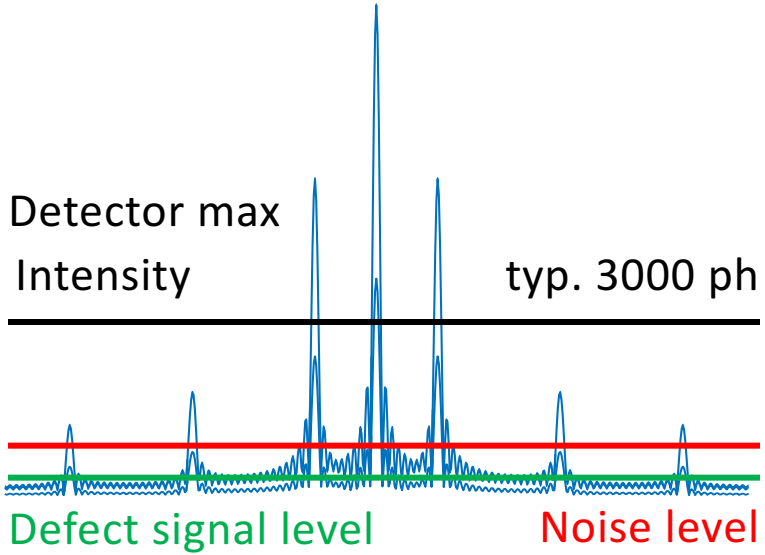
Phase map



Looks promising but…

There are two main challenges for successful implementation:

1. Detector dynamic range

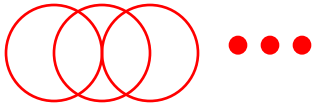


Low intensity – Signal buried in noise

High intensity – Peak saturation

2. Full mask inspection time

How much time does it take to scan a 100×100 mm^2 area with a 30 µm diameter probe?



We need at least 50% overlapping

100×100 mm^2 / 0.015×0.015 mm^2

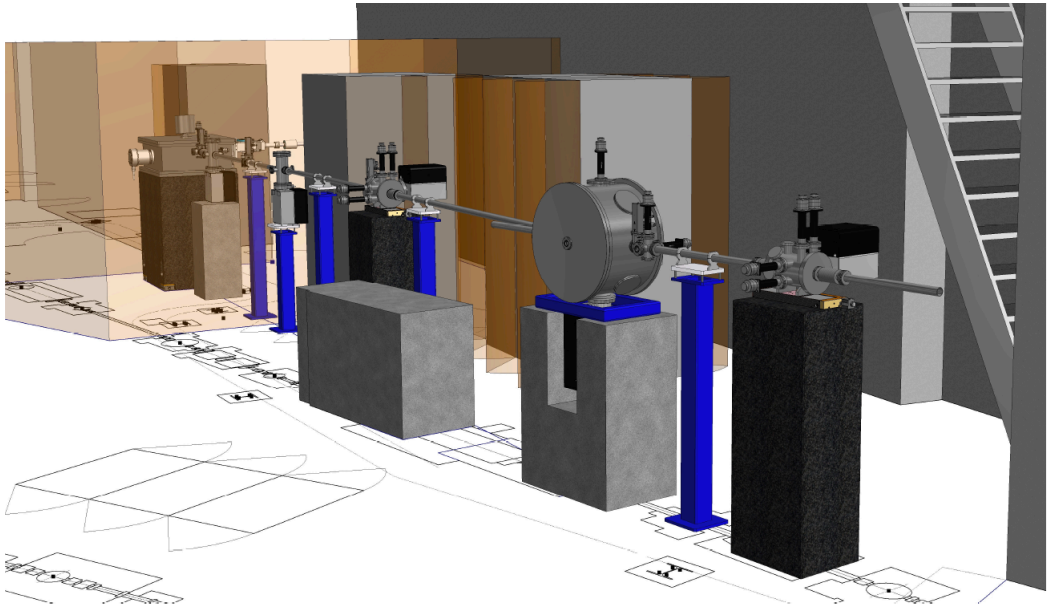
44000000 images!

Requires ~1800 Hz frame rate

RESCAN dedicated beamline at SLS

Designed and optimized for RESCAN

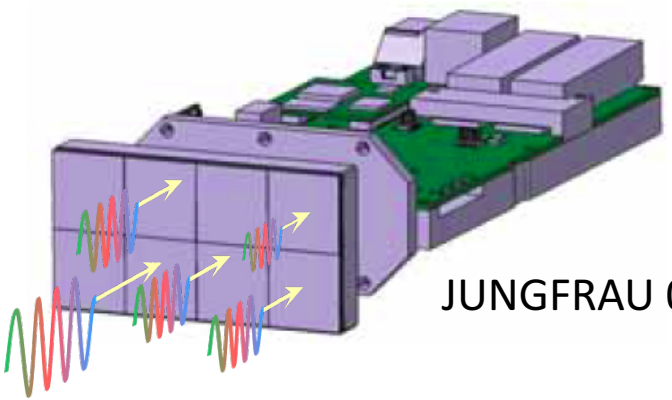
- Wavelength: 4 -14 nm
- Photon rate: 10^{11} -10^{12} Ph/s (Coherent flux on sample)
- Monochromaticity: 2000



A –*very*– fast detector

JUNGFRAU 0.2 – Developed at PSI for hard X-Ray applications (FEL)

Dynamic range	>10^6 (20 bit)
Module size	80mm X 40mm
Pixel size	75 microns
No of pixels	512 × 1024
Acquisition Rate	2000 Hz
Pixel Bleeding	No in both directions

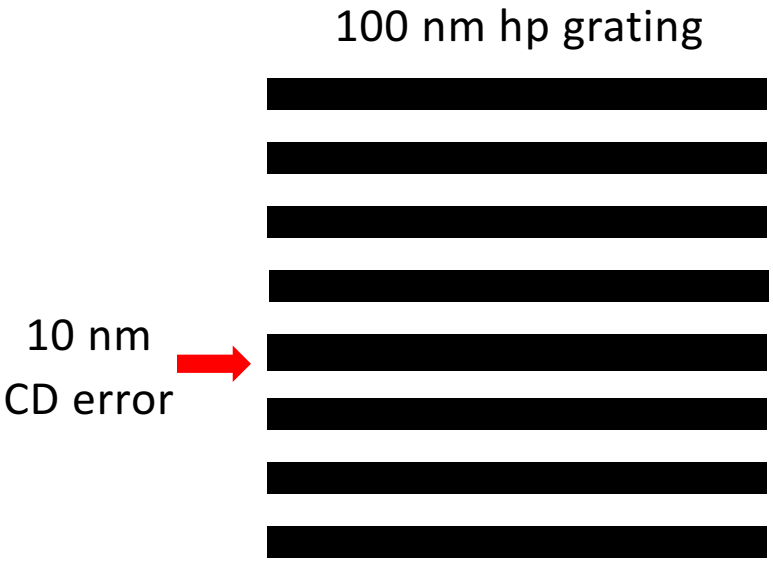


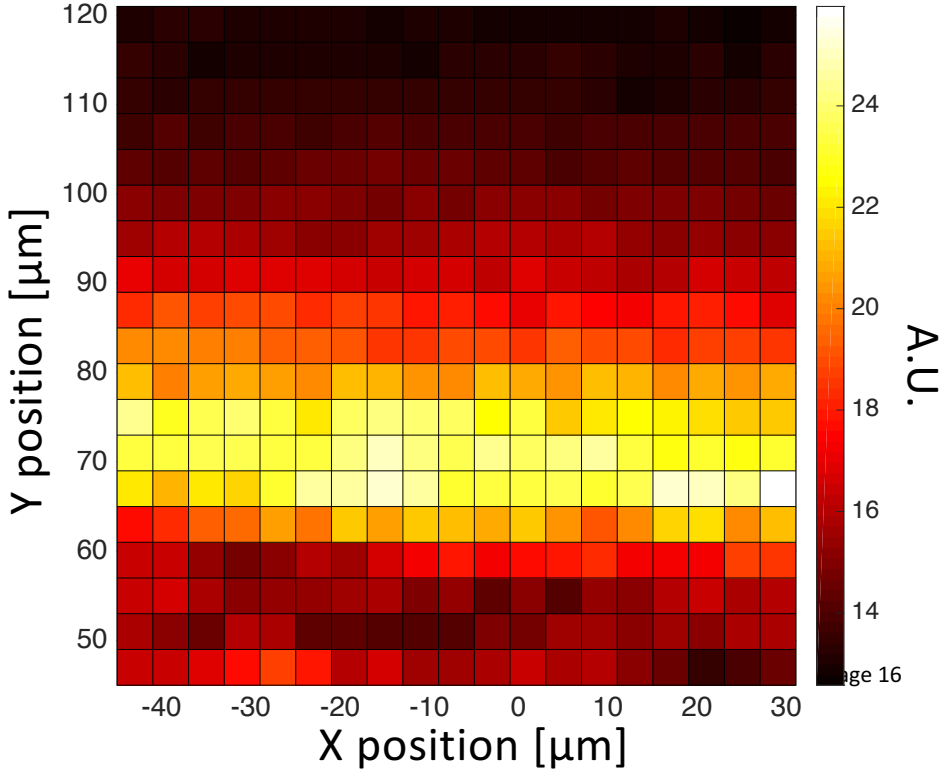
JUNGFRAU 0.2

P-MA-03 ***Dr. R.Rajendran*** A high frame-rate pixel detector with extended dynamic range for EUV imaging and mask metrology.

Defect inspection at 500 Hz

Recent data.

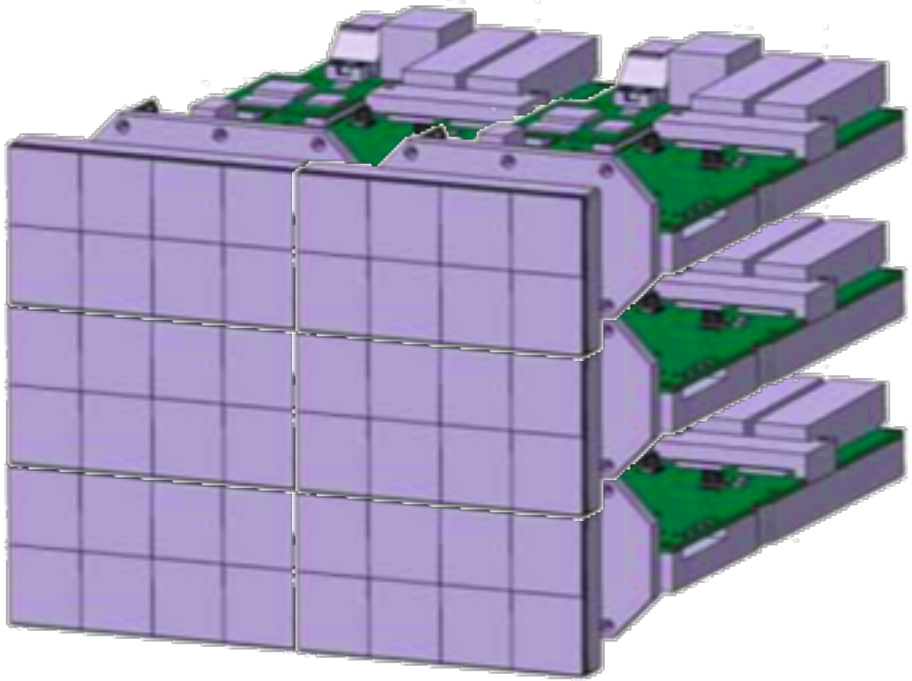




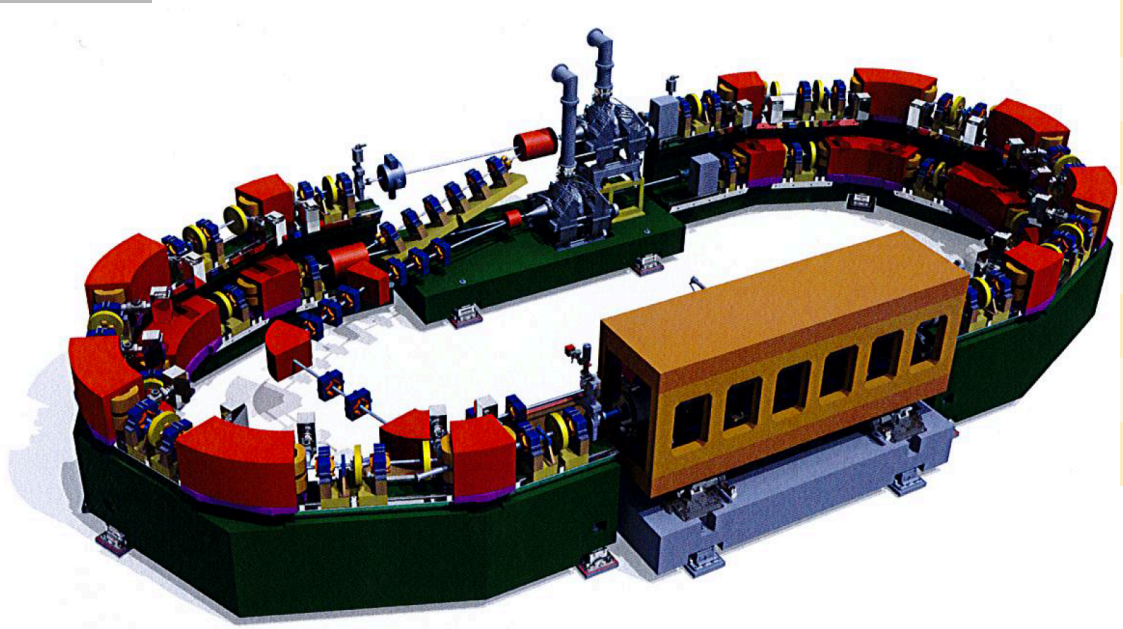
Multi-module detector

Jungfrau detector upgrade

- Up to six independent modules. No decrease in acquisition speed.
- EUV optimized. Quantum efficiency increases from 3% to 50%.



Compact EUV Metrology Source „COSAMI“



Wavelength	13.5 nm
Flux	>100 mW
Brilliance	> 10^6 W/(mm^2 · strd)
Beam energy/beam current	430 MeV/150 mA
Pulse structure	~50 ps every 2 ns
Injection system	Top-up mode
Footprint	5m × 12m

Conclusion

The RESCAN platform can be a viable approach to fill the gap in actinic reticle defect inspection.

The key technology is available today.

Additional component development and integration is in progress:

- Fast detector
- Improved algorithms for inspection and image reconstruction
- Compact EUV source

Wir schaffen Wissen – heute für morgen

We create knowledge – today for tomorrow

Aknowledgements

- M. Vockenhuber
- M. Kropf
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- A. Mozzanica
- S. Redford
- B. Schmitt