Full Field Imaging by the ASML Alpha Demo Tool

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EUVL Symposium Barcelona; 16 – 18 Oct 2006

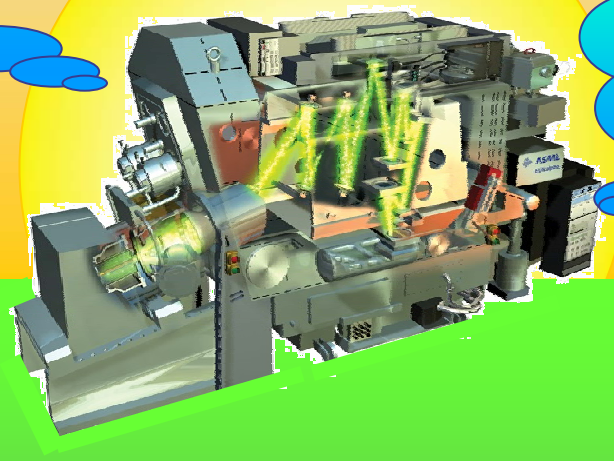
The first full field EUV Litho tool in the world….

New system

First Optical Column integration

Full Field Imaging

Sub 50 nm
Mixed features



Does the Alpha Demo Tool image as promised ?

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Contents

- Metrology setup
  - Adjusting the Projection Optics Box (POB) using the Transmission Image Sensor (TIS)
- Resist imaging
  - Line / Spaces
    - CDU; LWR; mask shadowing
  - Contact Holes
- Conclusions

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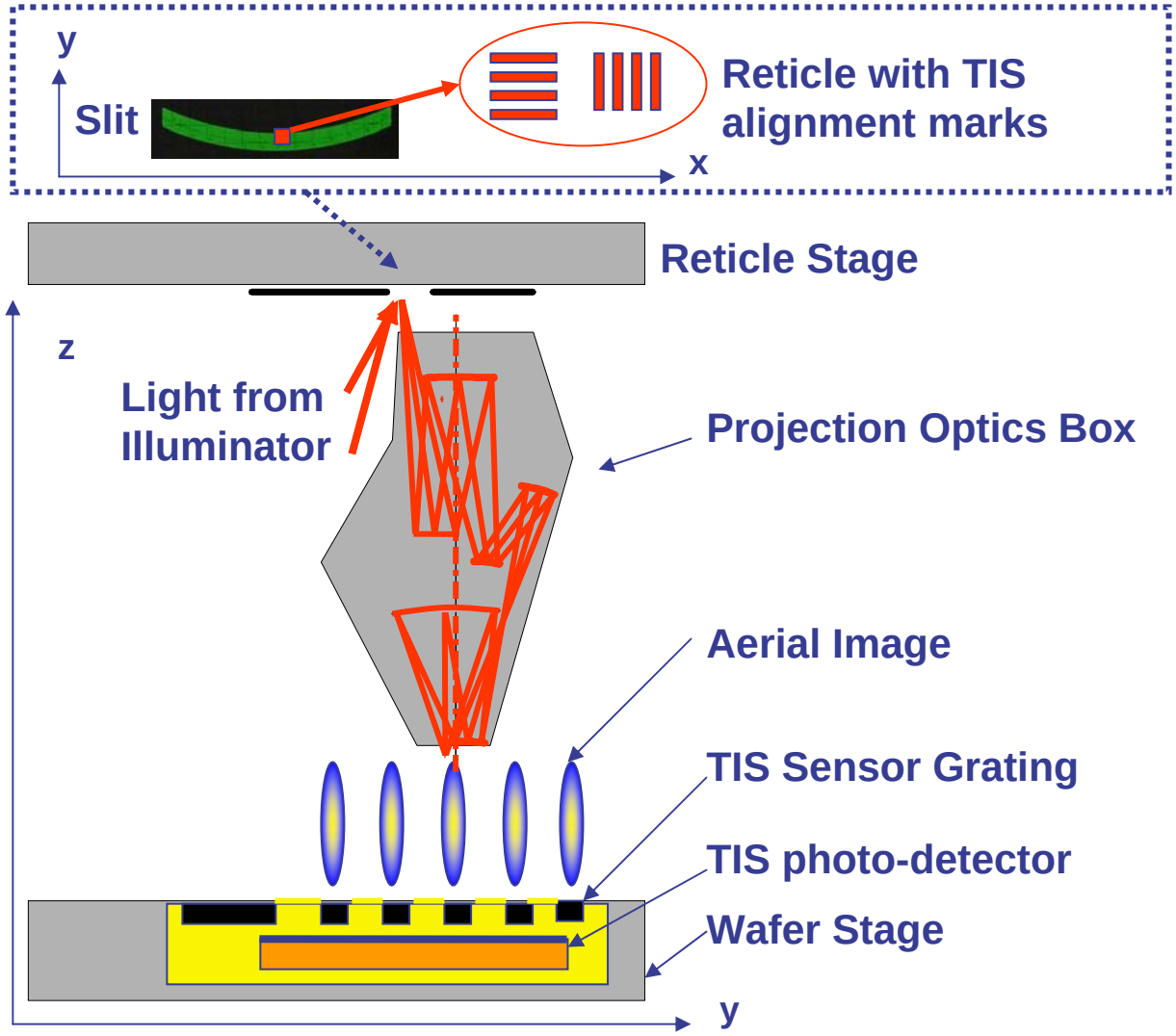
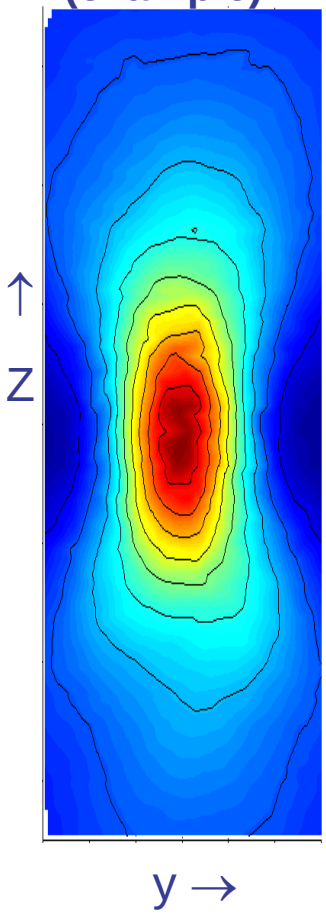
EUV Metrology based on well-known principles: Transmission Image Sensor (TIS)



TIS Aerial Image (example)



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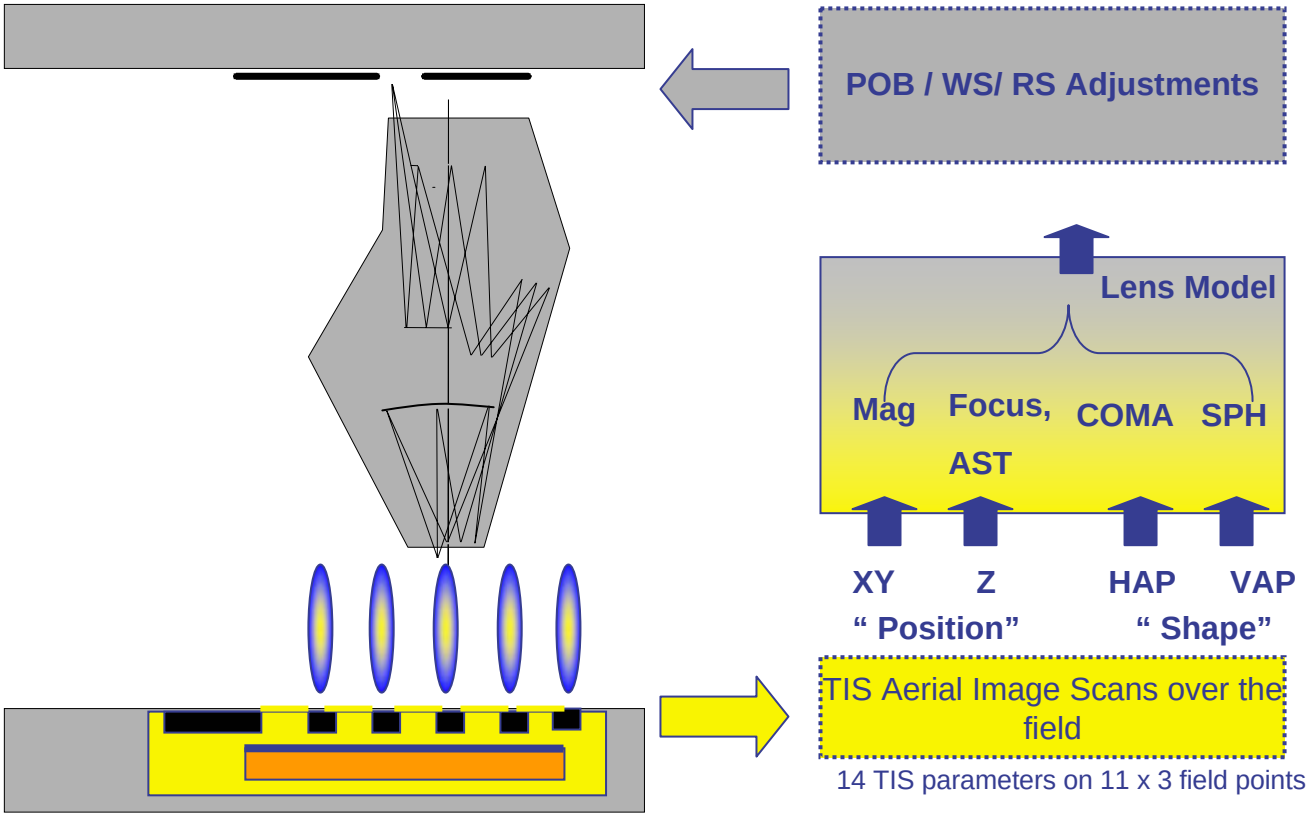
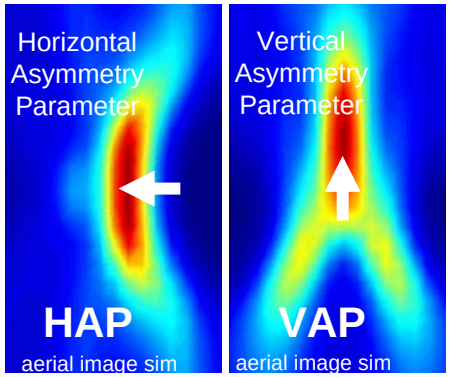
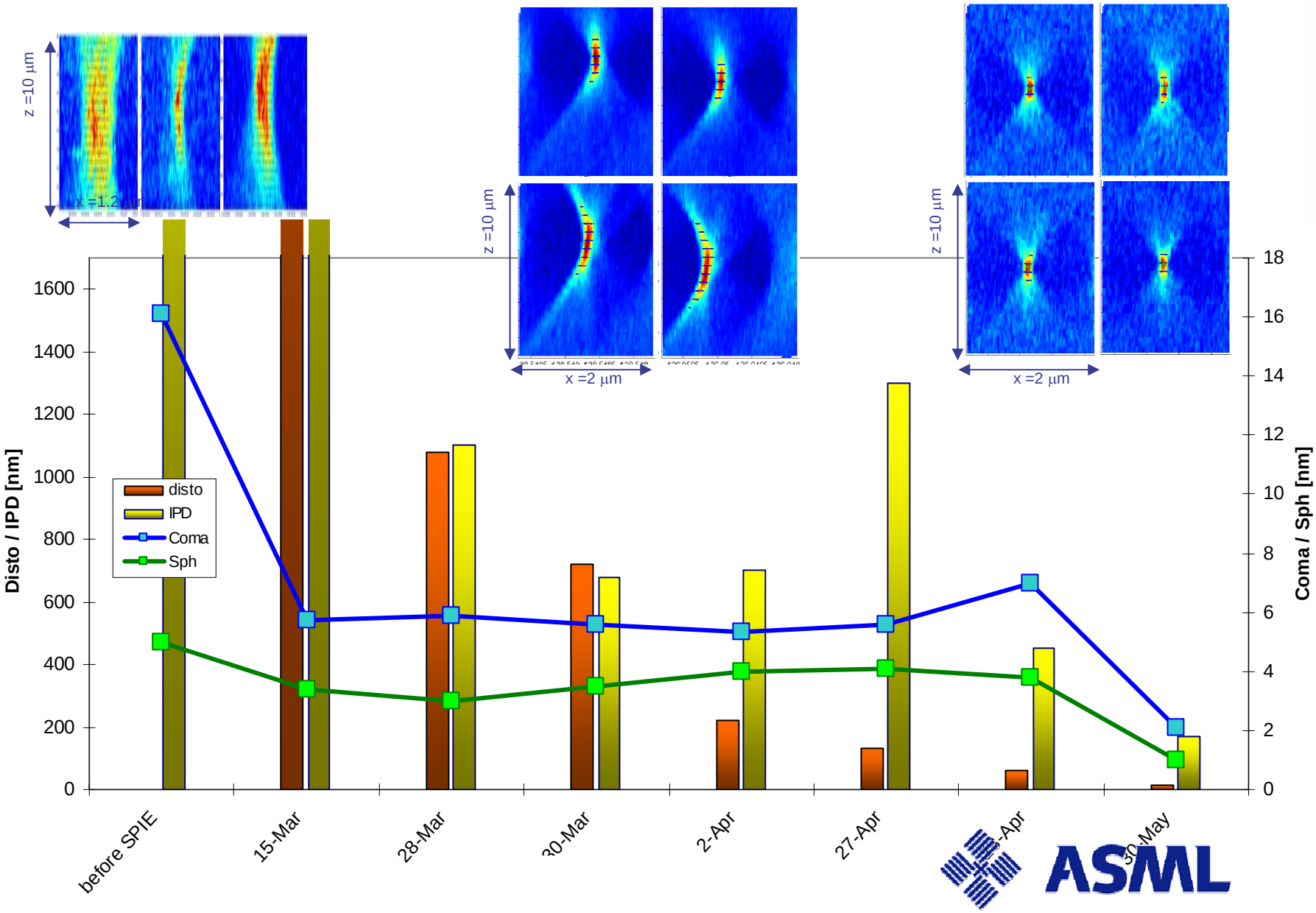
System adjustment using the TIS



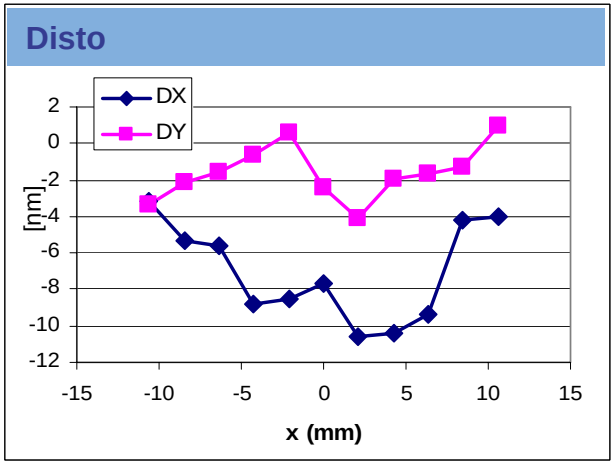
All of this is part of the tool metrology SW. The concept is common to TWINSCAN™, but the actual algorithms and implementation is unique to Alpha

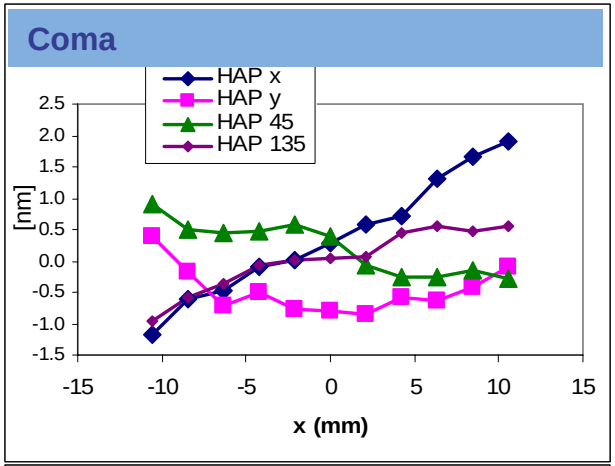


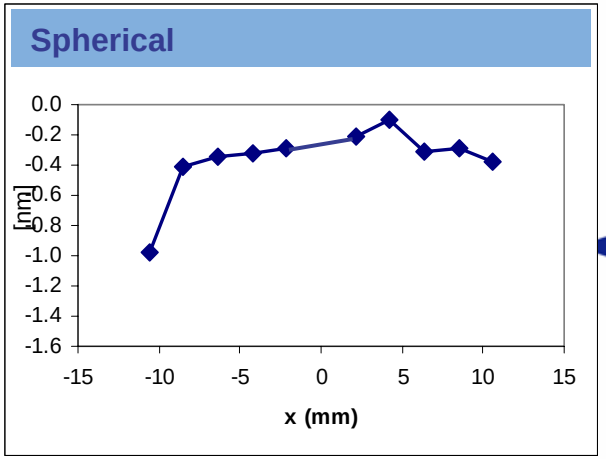
Tool Metrology progress has been remarkable

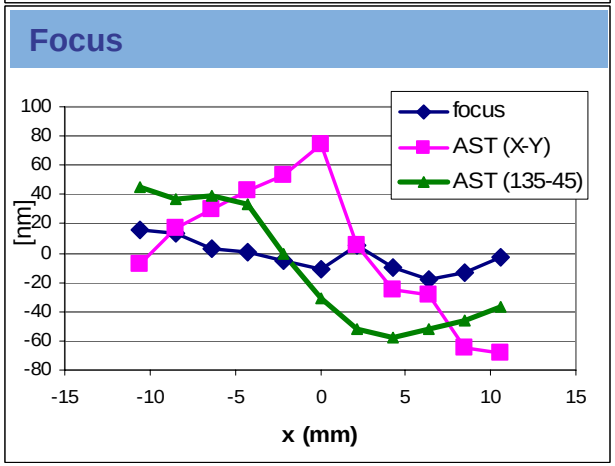


TIS measures lumped aberrations through slit









- Profile of lowest order aberrations can be measured over the slit

- Aberrations at same level in system as at Zeiss lens adjustment

- ➔ TIS metrology enables projection optics optimization

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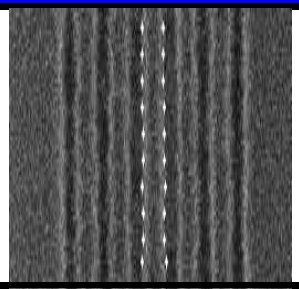
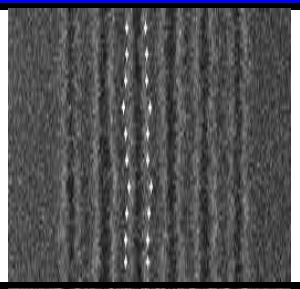
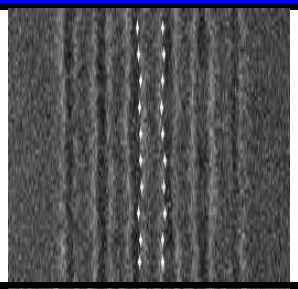
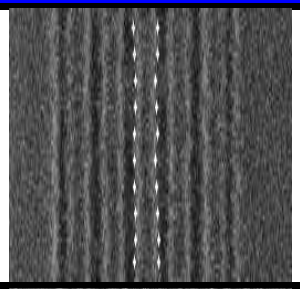
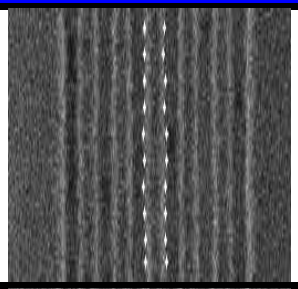
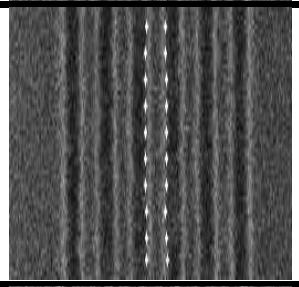
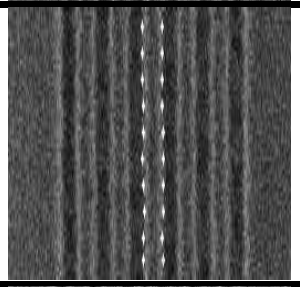
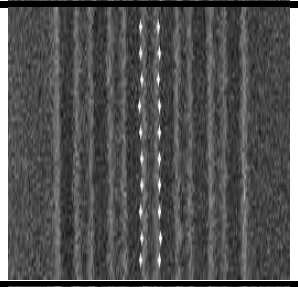
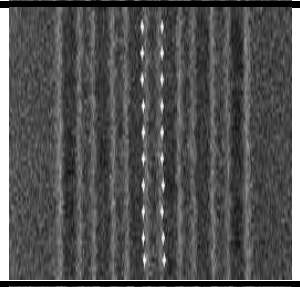
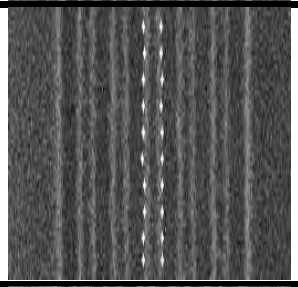
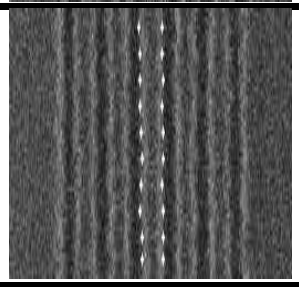
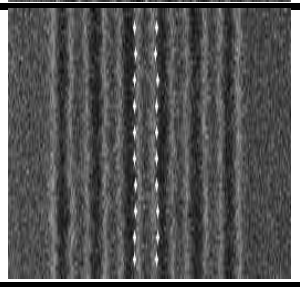
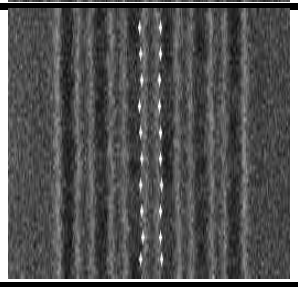
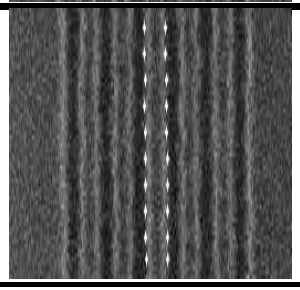
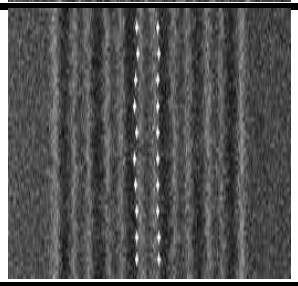
40nm horizontal lines print through focus and through the slit

Resist: MET-2D (XP 5271-E)
Dose ~16-17 mJ/cm^2
NA=0.25
σ= 0.5 (conventional illumination)
no process development
Xe Source

Focus (nm)	Slit Position (mm)				
	-10.6	-4.24	0	4.24	10.6
120					
0					
-120					

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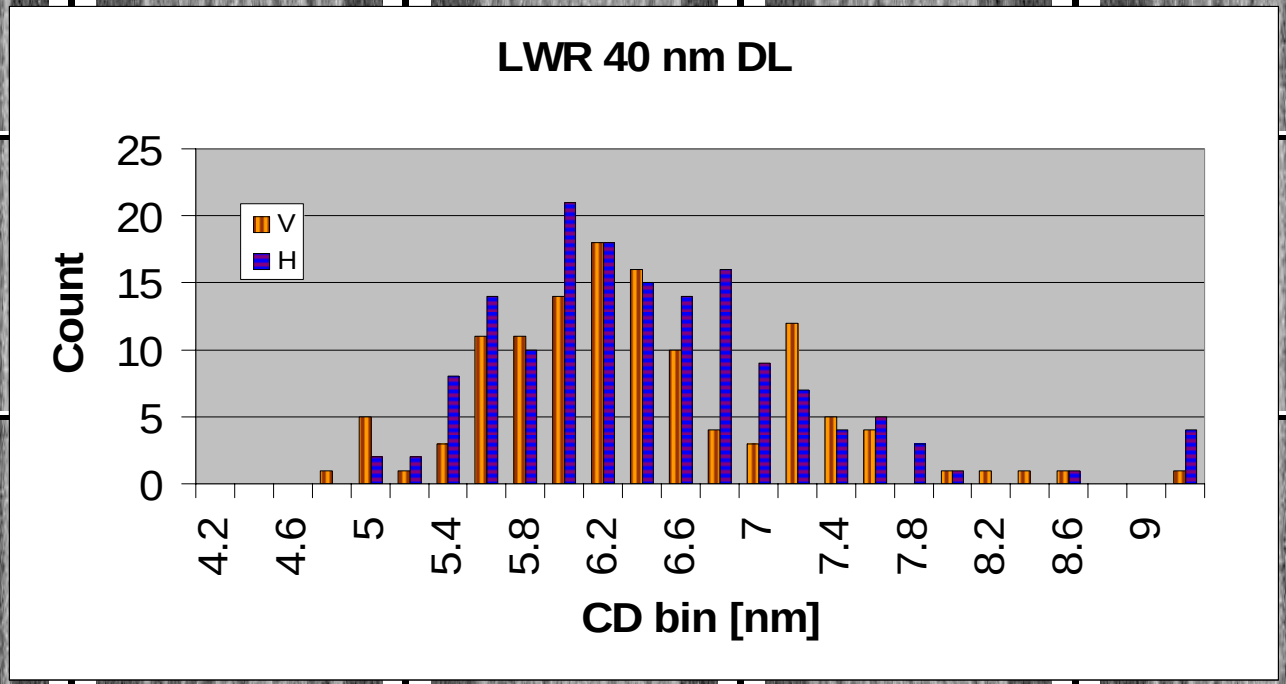
40nm vertical lines print through focus and through the slit

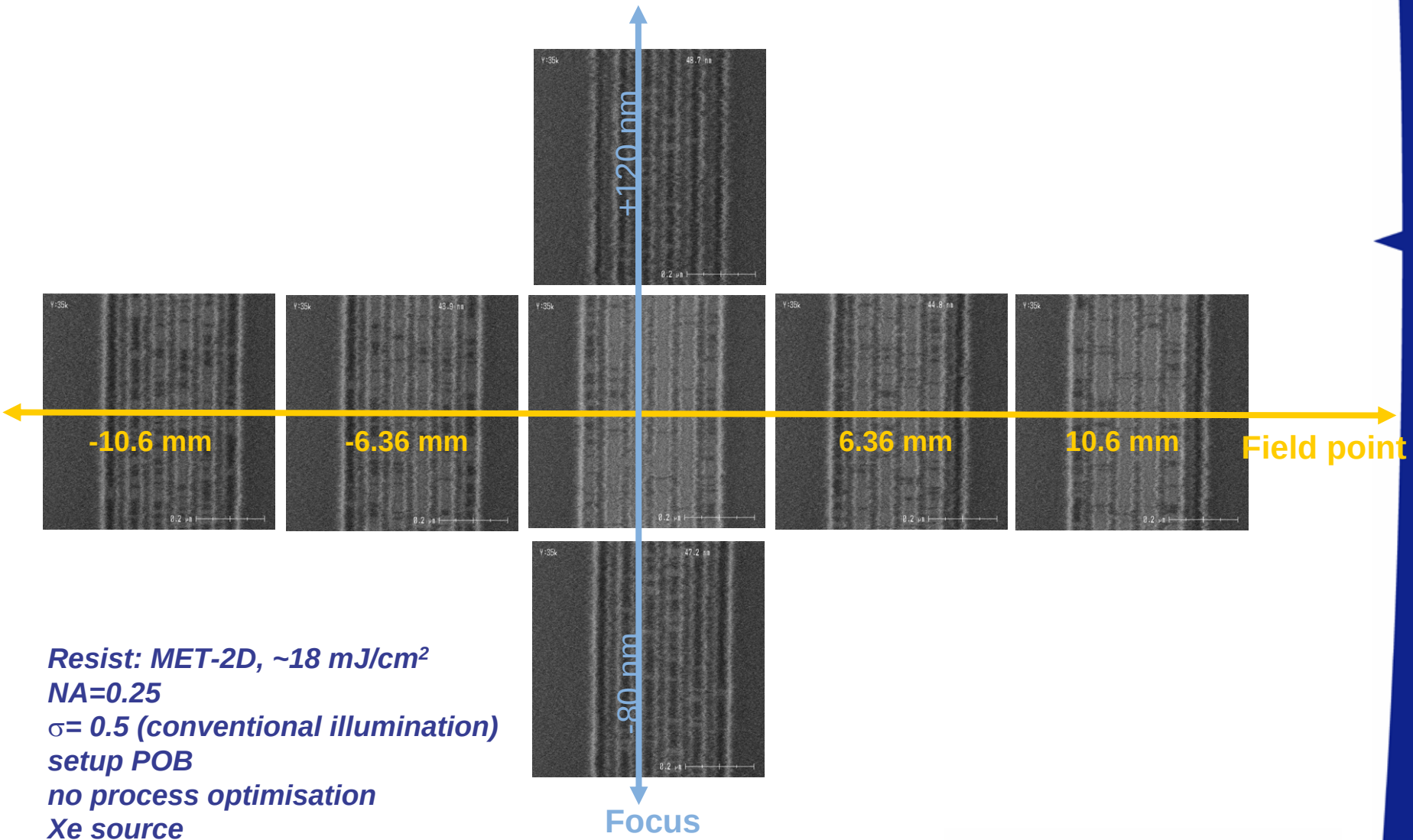
Resist: MET-2D (XP 5271-E)
Dose ~16-17 mJ/cm^2
NA=0.25
σ= 0.5 (conventional illumination)
no process development
Xe Source

Focus (nm)	Slit Position (mm)				
	-10.6	-4.24	0	4.24	10.6
120					
0					
-120					



ASML

Full field, through focus 35 nm lines



Resist: MET-2D, ~18 mJ/cm²
NA=0.25
σ= 0.5 (conventional illumination)
setup POB
no process optimisation
Xe source

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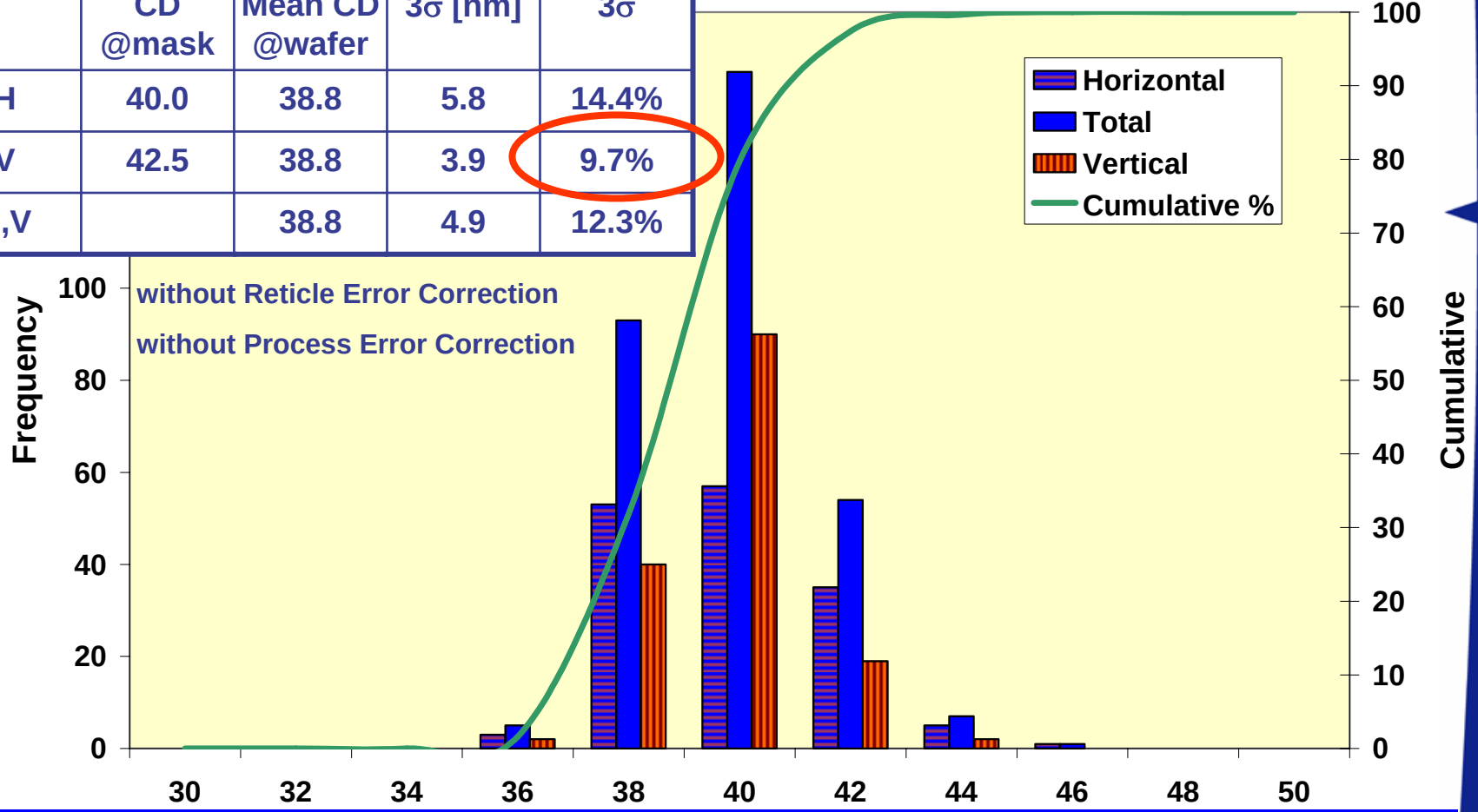
40 nm DL across wafer CDU < 6 nm (< 15%)

	CD @mask	Mean CD @wafer	3σ [nm]	3σ
H	40.0	38.8	5.8	14.4%
V	42.5	38.8	3.9	9.7%
H,V		38.8	4.9	12.3%



➔ First Across Wafer CDU data on EUV …approaching target

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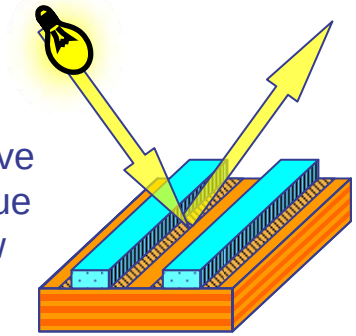
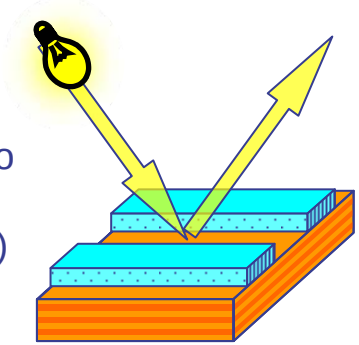
Mask shadowing compensation

- Mask shadowing results in a line thickening of H lines w.r.t. V lines

H line sees effective line broadening due to Mask Shadow



V line sees no broadening (@slit center)



- We applied a reticle bias for V lines of +2.5 nm (1x) w.r.t. to H lines to bring both H and V to target.

	CD @mask	Mean CD @wafer	3σ [nm]	3σ
H	40.0	38.8	5.8	14.4%
V	42.5	38.8	3.9	9.7%
H,V		38.8	4.9	12.3%

	CD mask	
pick3	36.25	
pick4	37.5	
pick5	38.75	
pick6	40	← H Lines
pick7	41.25	
pick8	42.5	← V Lines
pick9	43.75	

➔ Compensation for Mask shadowing shows correct signature

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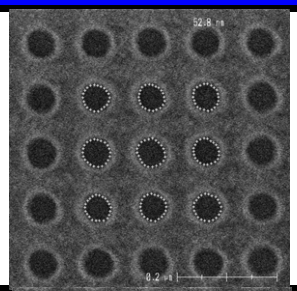
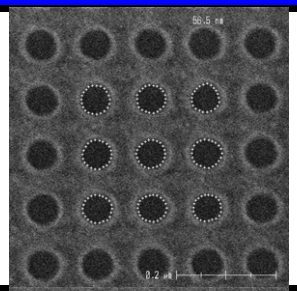
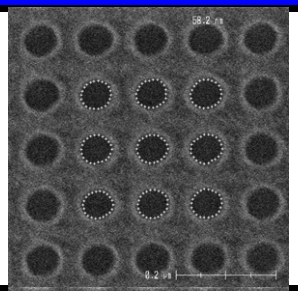
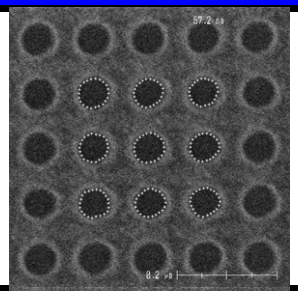
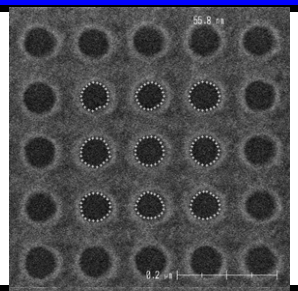
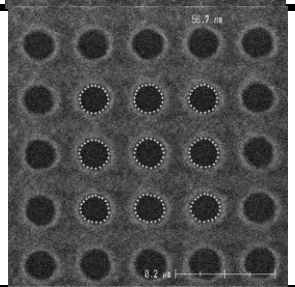
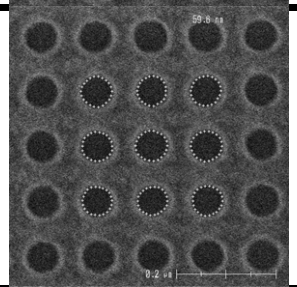
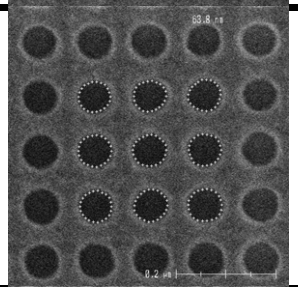
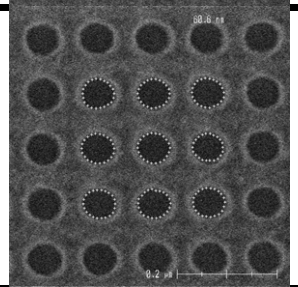
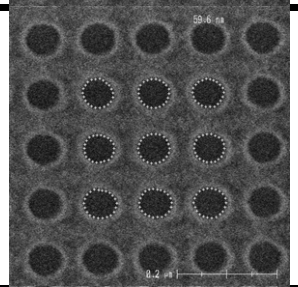
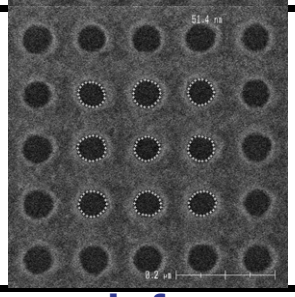
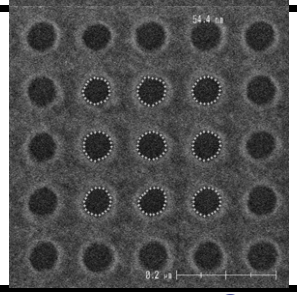
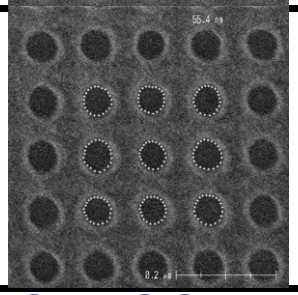
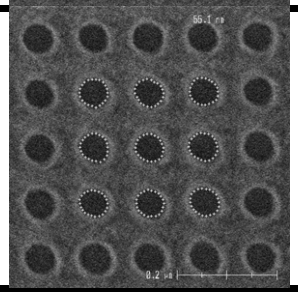
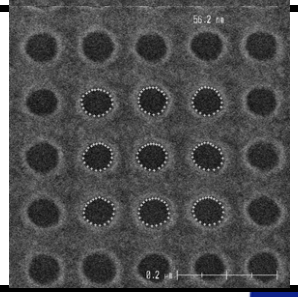
Aligned 55nm contact holes print through focus and through the slit

Resist: MET-2D (XP 5271-E)
Dose ~30 mJ/cm^2
NA=0.25
σ= 0.5 (conventional illumination)
no process development

Focus (nm)	Slit Position (mm)				
	-10.6	-4.24	0	4.24	10.6
-120					
NF					
120					

Through focus: Mean = 57.9nm 3σ = 8.8nm

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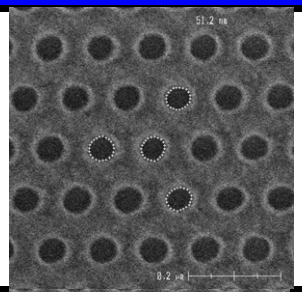
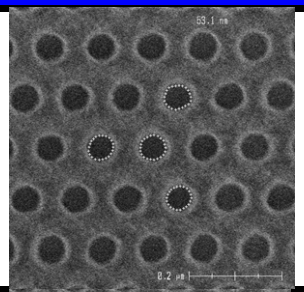
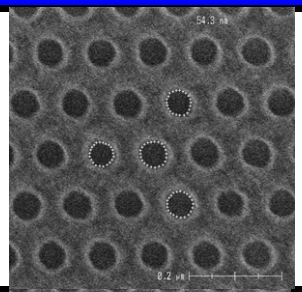
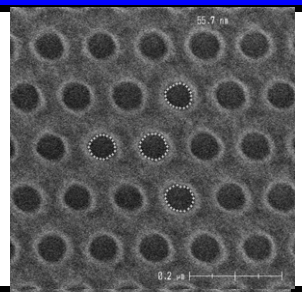
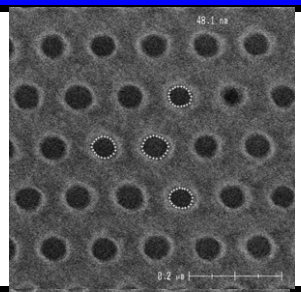
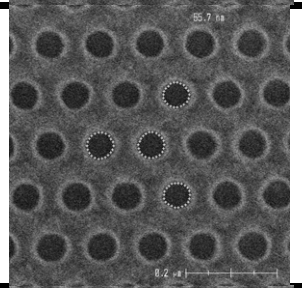
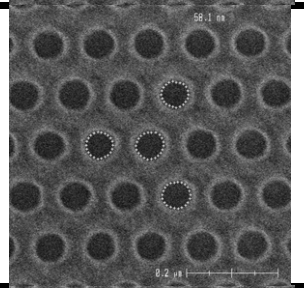
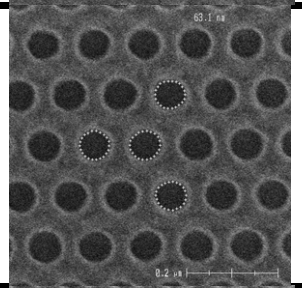
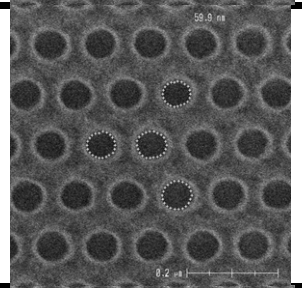
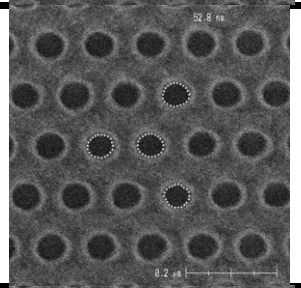
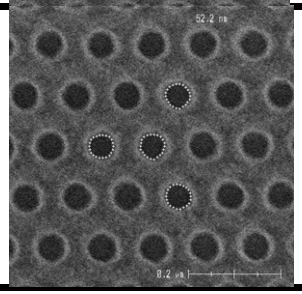
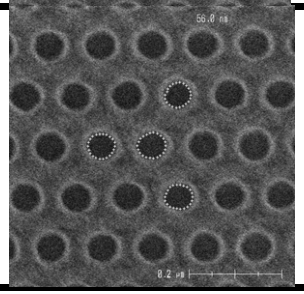
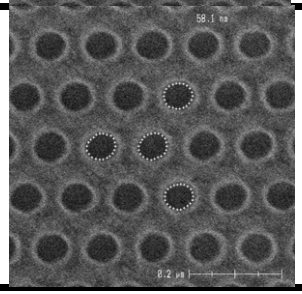
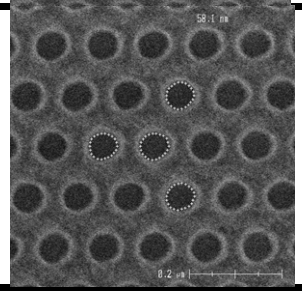
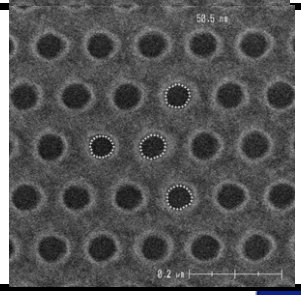
Staggered 55nm contact holes print through focus and through the slit

Resist: MET-2D (XP 5271-E)
Dose ~30 mJ/cm^2
NA=0.25
σ= 0.5 (conventional illumination)
no process development

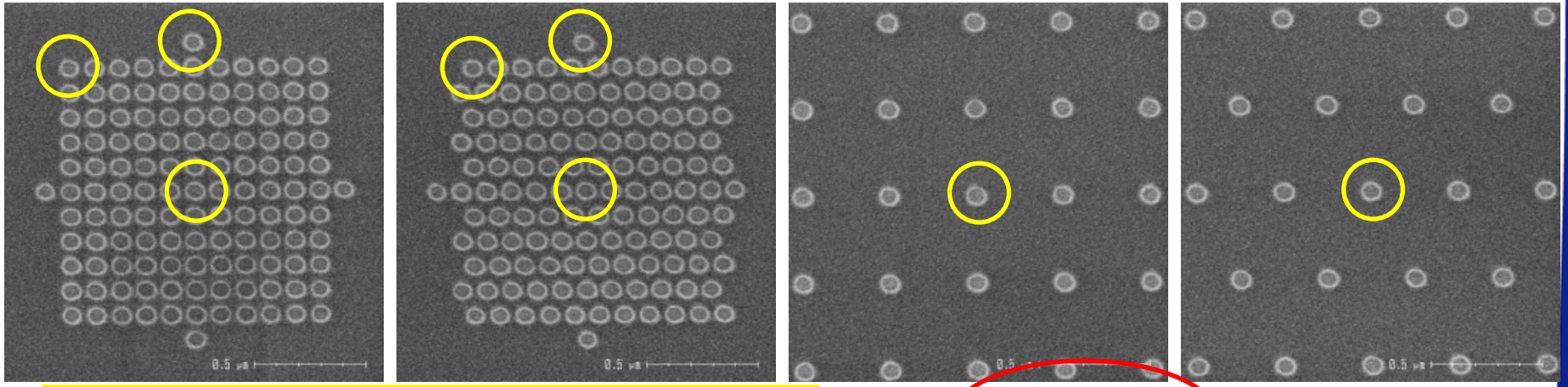
Focus (nm)	Slit Position (mm)				
	-10.6	-4.24	0	4.24	10.6
-120					
0					
120					

Through focus: Mean = 57.8nm 3σ = 8.1nm

ASML

The power of EUV - 55nm dense and iso contact holes print simultaneously – same dose & focus!

Dense (aligned) | Dense (staggered) | Iso (aligned) | Iso (staggered)



All at same conditions:

-NA / Illumination / focus /dose

-No OPC applied!

55 nm CH

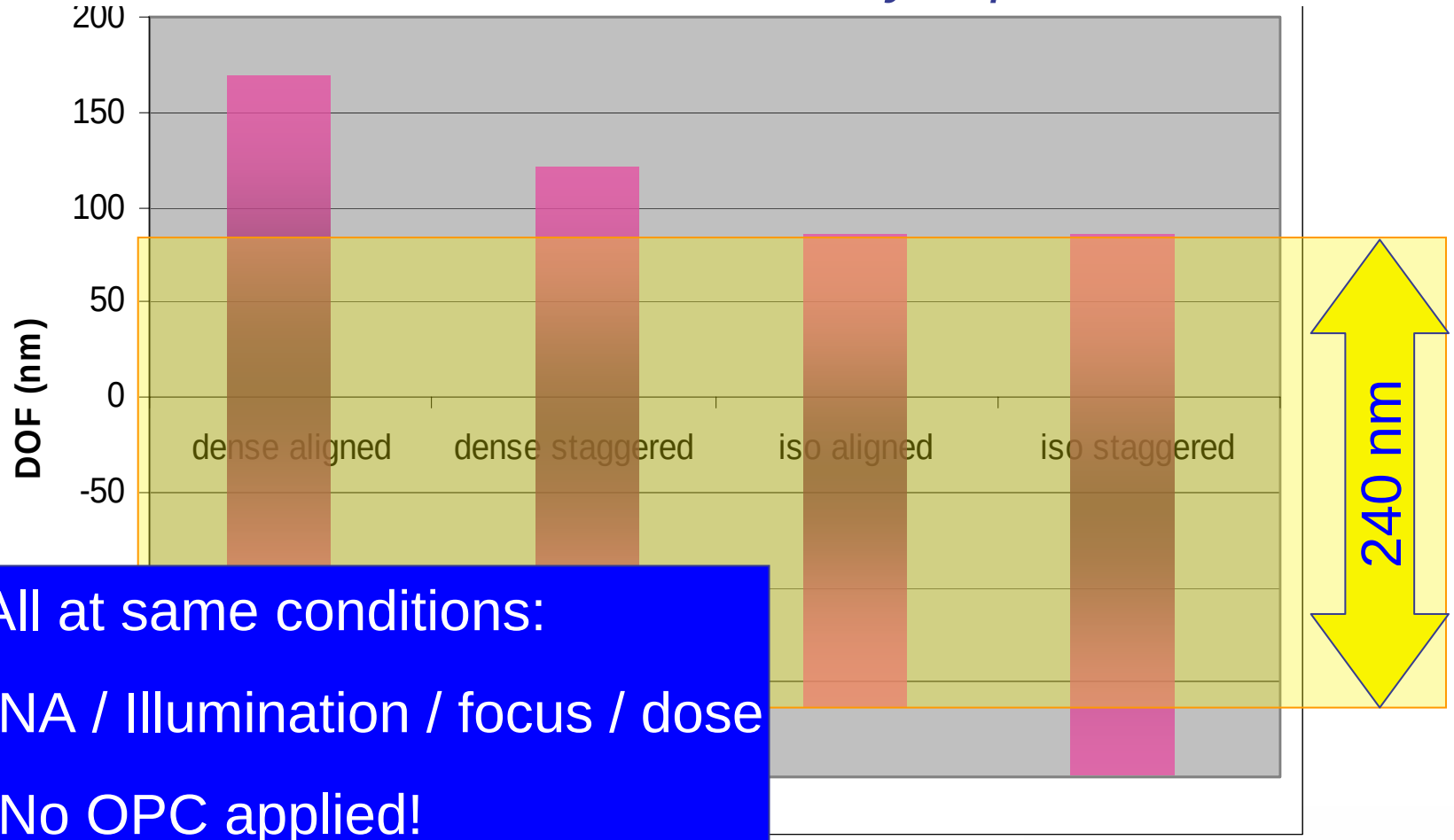
Resist: MET-2D ~30 mJ/cm2

NA=0.25, σ=0.5

ASML

240 nm Overlapping DOF for 55 nm dense aligned CH; dense staggered CH and iso CH

Nearly impossible with 193 !



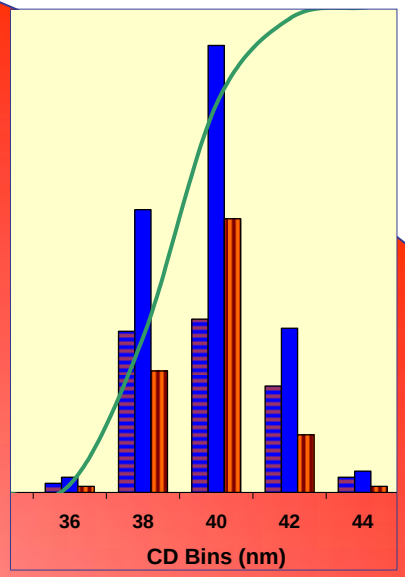
All at same conditions:

-NA / Illumination / focus / dose

-No OPC applied!

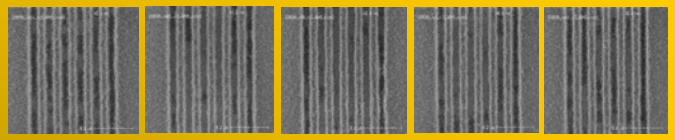
ASML

Imaging integration in rapid pace…



40 nm CDU Across Wafer

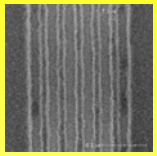
July 2006



left center right

40 nm Across Slit

May 2006



40 nm Single Fieldpoint

Feb 2006 (@SPIE)

Achieved with the Setup-POB

ASML

Conclusions
Alpha Demo Tool Imaging exceeds its promises

- With the very first system
  - Setup-POB with higher flare, and WFE
  - limited resist contrast
  - no process optimization

  ….the Alpha Demo Tool is showing 40-nm dense lines across wafer and 55-nm contact hole images

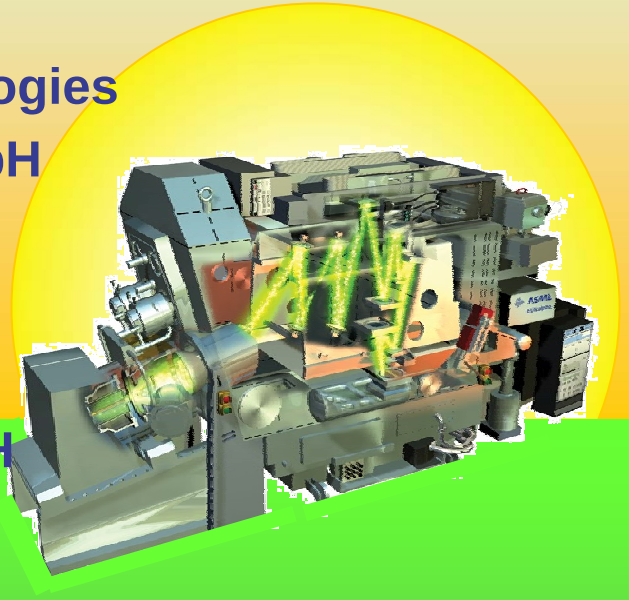
  … even 35 nm lines are seen !!!
- EUV imaging shows predictable behaviour
  - aberrations under control
  - first results on global mask shadowing corrections
- Better results expected soon ….
  - AD1 and AD2 will have Projection Optics with enhanced performance

ASML

Acknowledgement

Thanks to a great team effort at…

- ASML
- Zeiss
- TNO
- Philips Applied Technologies
- Philips Extreme UV GmbH
- PTB-BESSY
- FOM-Rijnhuizen
- Rohm & Haas
- International SEMATECH
- …and many others

with support from national governments, MEDEA+, and European Commission

Thank You !