Characterization of NXE3100 in view of 1Xnm node DRAM patterning

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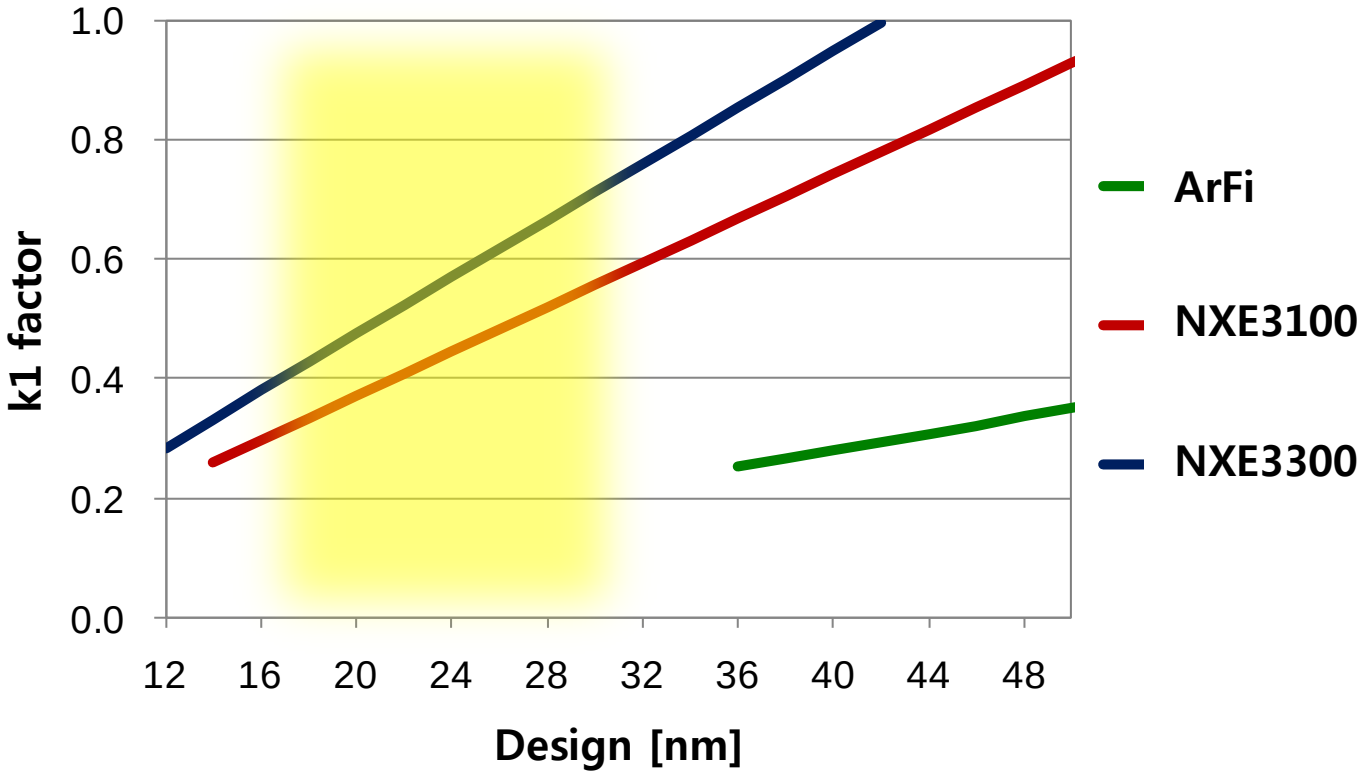
SK hynix

Outline

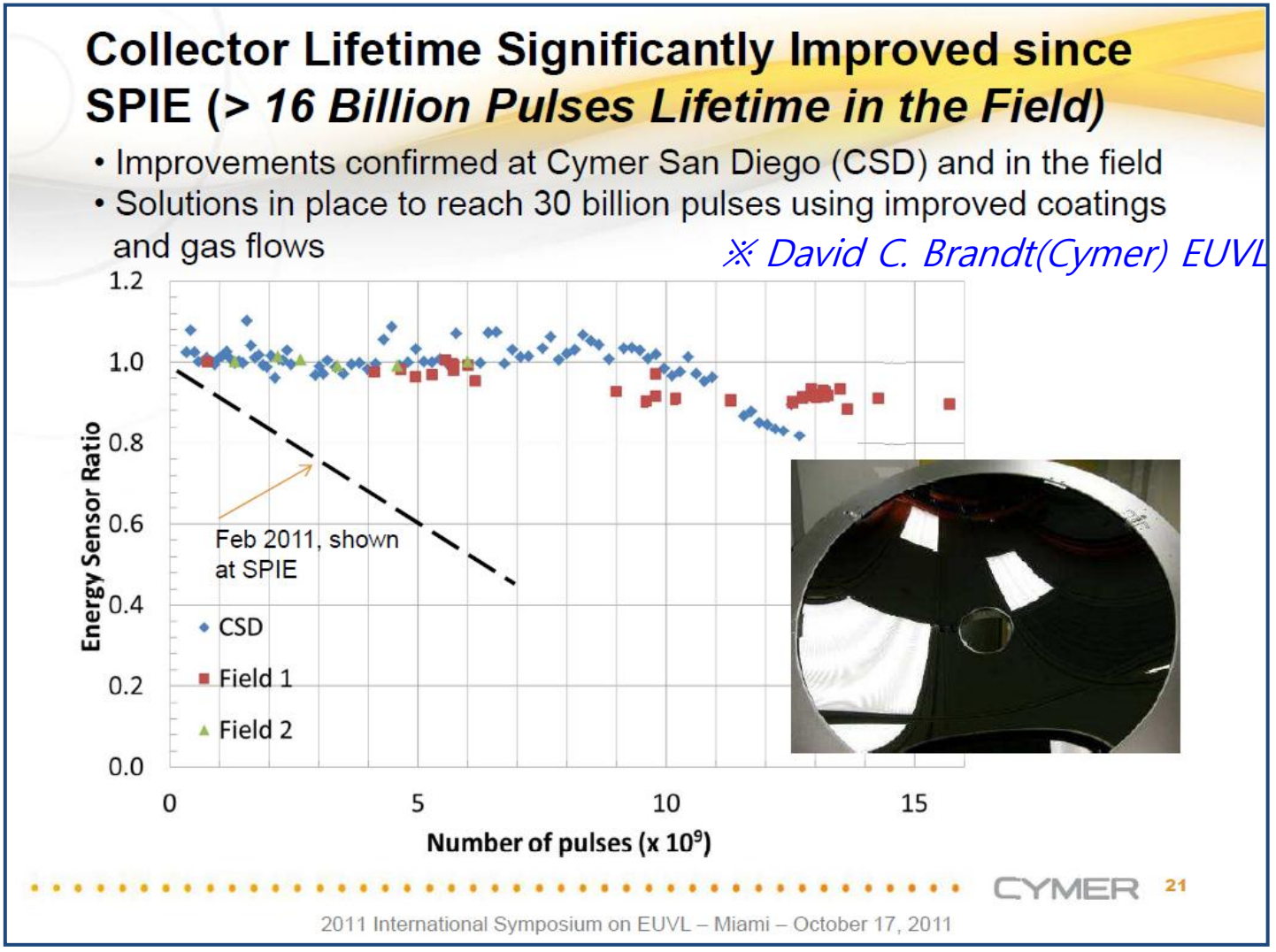
- ✓ **Collector degradation in EUV**
  - Collector life
  - Effect of collector degradation on patterning
- ✓ **Aberration effect in NXE3100**
  - RCDA : ADT vs. NXE3100
  - IPD with 1Xnm node contact hole
  - Across slit CD variation
  - Illumination mode dependency
- ✓ **Summary**

High k1 Lithography with EUV



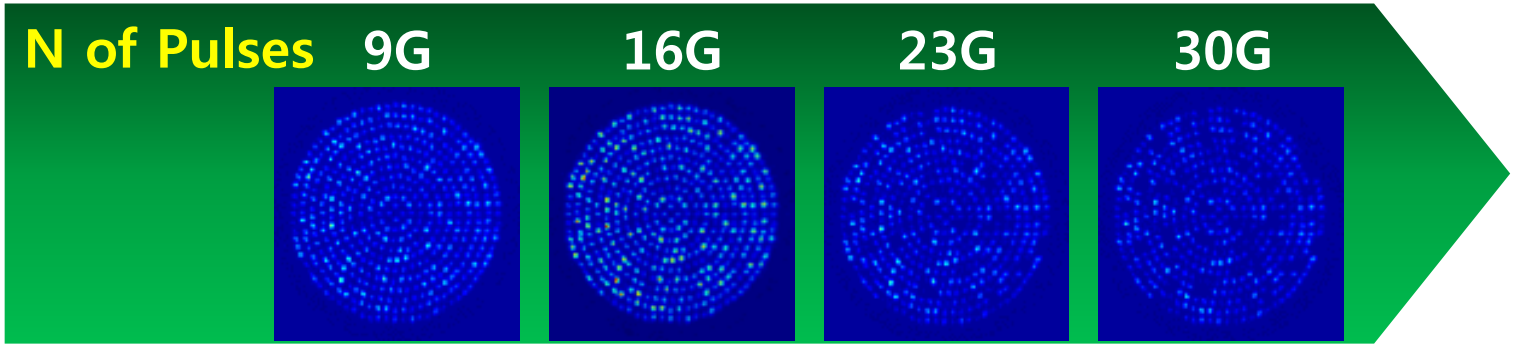
Is EUV at ~ 0.5 k1 free from illumination imperfection and aberration ?

Reflectivity Degradation

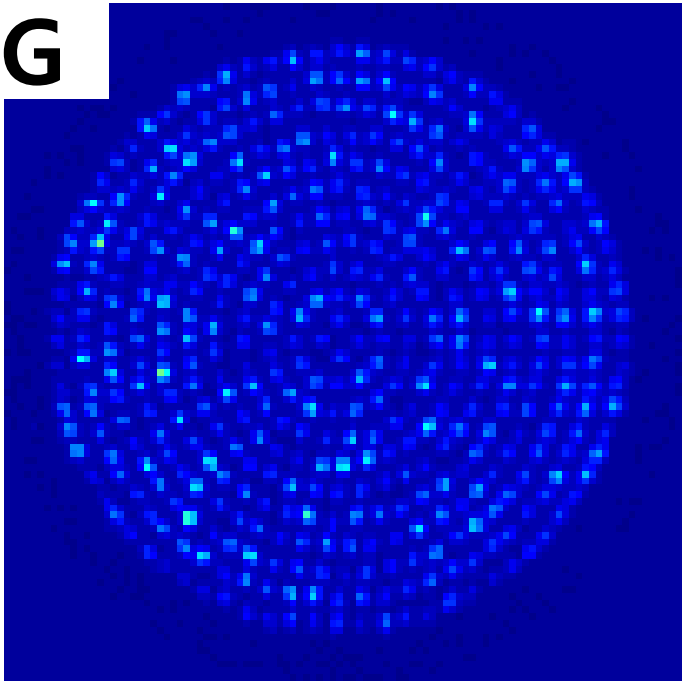


What else besides reflectivity degradation of collector ?

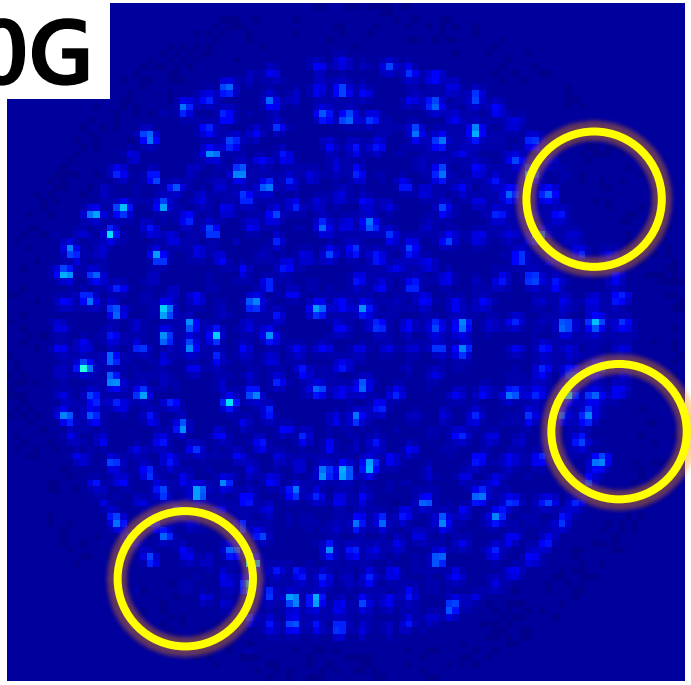
Illumination Pupil vs. Collector Life



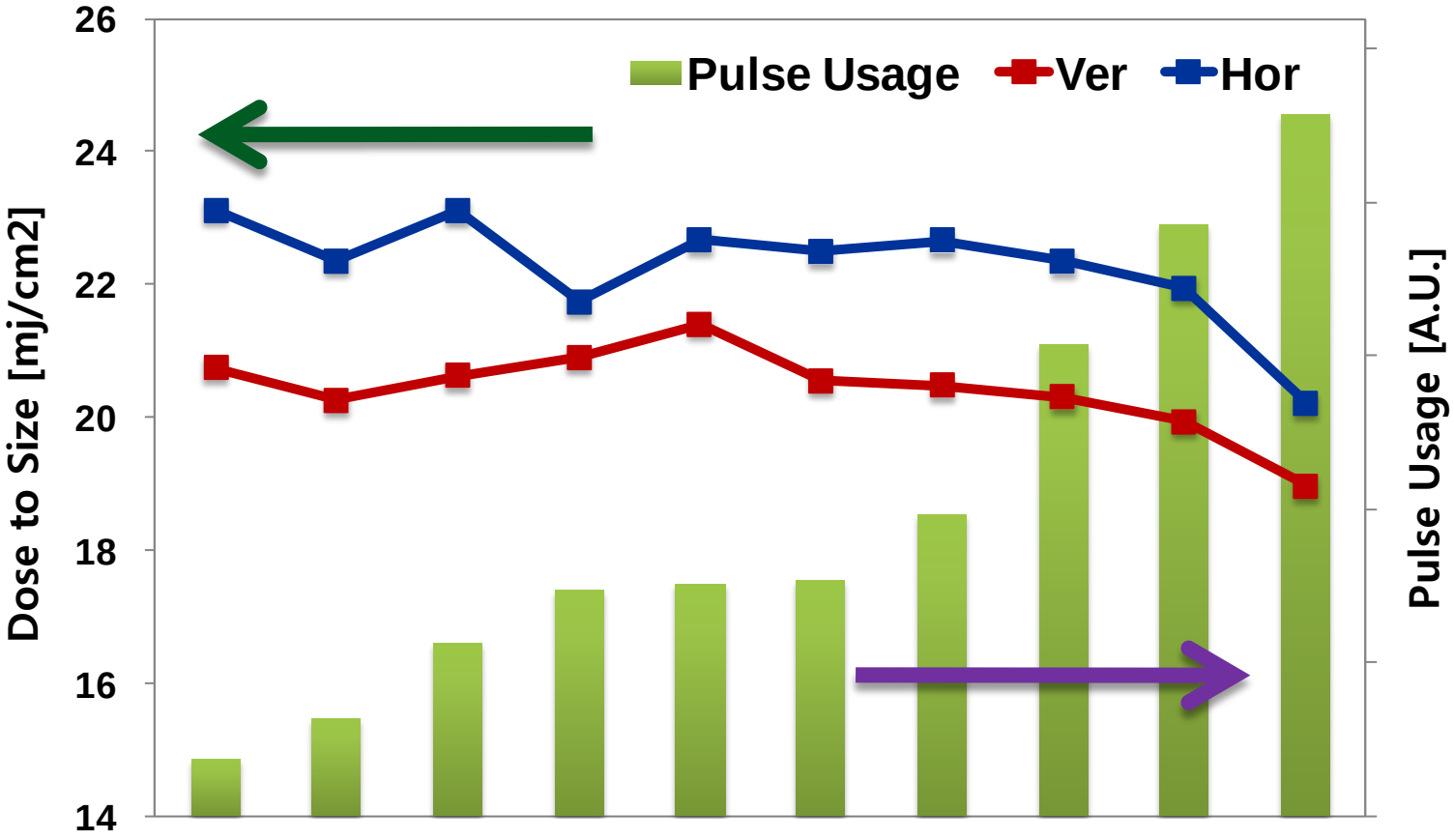
9G



30G



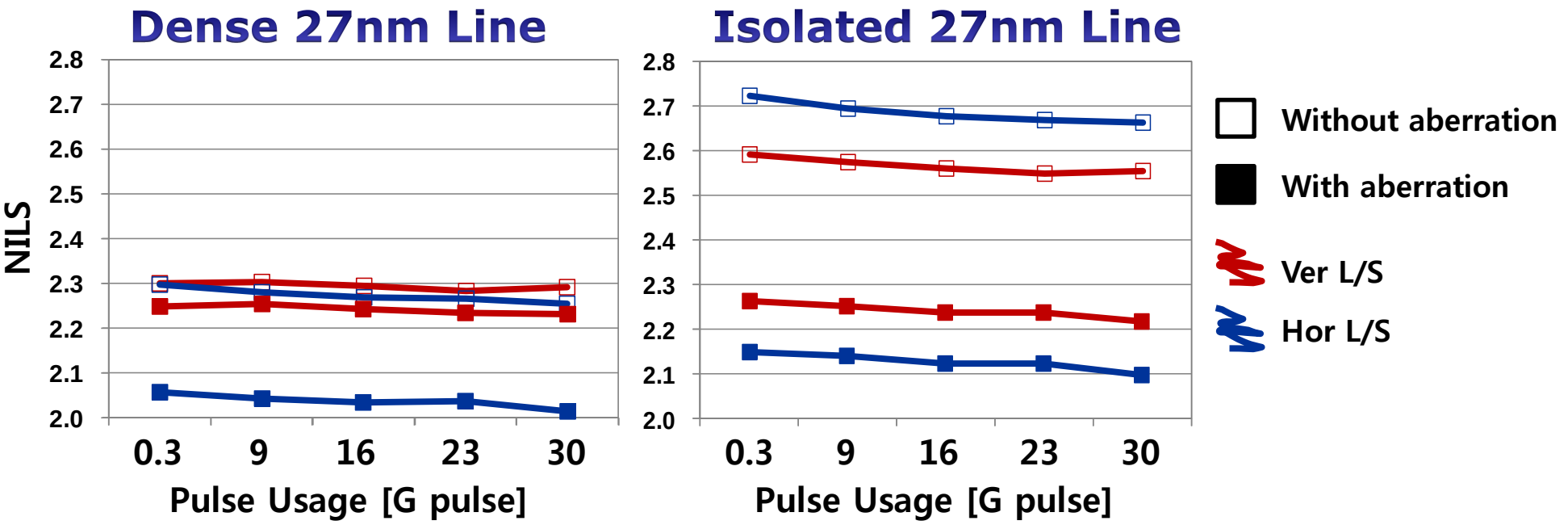
DtS Monitoring



Dose to size had remained stable for most of collector life except for 10% down at the end of life

Illumination Pupil Change on Patterning

- **Simulation with real pupil and aberration**

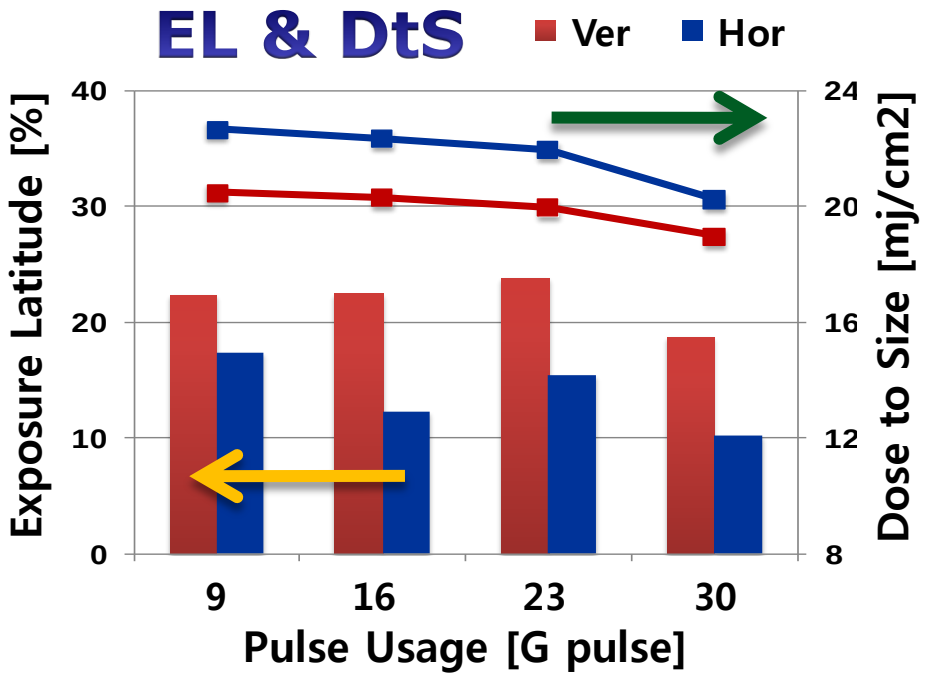


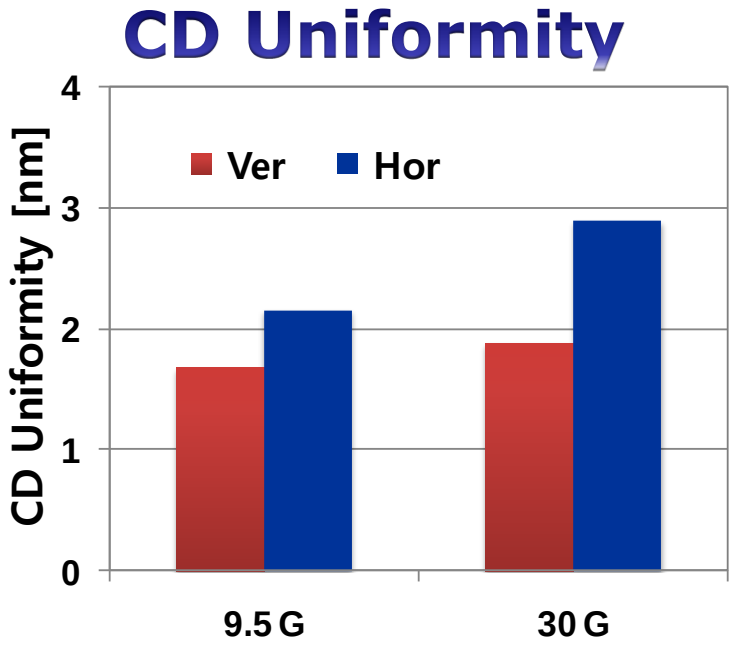
NILS decreased slightly, as collector degraded

Tendency intensified at the end of collector life with aberration taken into account

Experiment Results

- 27nm dense lines and spaces





EL deteriorated as collector degradation progress matched result of significant change at the end of life as simulation

Outline

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  - Effect of collector degradation on patterning
- ✓ **Aberration effect in NXE3100**
  - **RCDA : ADT vs. NXE3100**
  - **IPD with 1Xnm node contact hole**
  - **Across slit CD variation**
  - **Illumination mode dependency**
- ✓ Summary

Previous Study on Aberration of ADT

※ S. Koo(SK hynix) EUVL Symposium 2009

EUV Symposium (2009, Oct.)

IPD + Astigmatism?

Focus

EUV Symposium (2009, Oct.)

Simulation of Astigmatism

- Simulated as
- Z5 : -0.75nm

Exp

RCDA

0.20
0.10
0.00
-0.10
-0.20

-0.28 -0.14

Ex
vs. Si

EUV Symposium (2009, Oct.)

Simulation of COMA

- Simulated C

EXP

RCDA

0.1
0.08
0.06
0.04
0.02
0
-0.02

20 40

Half

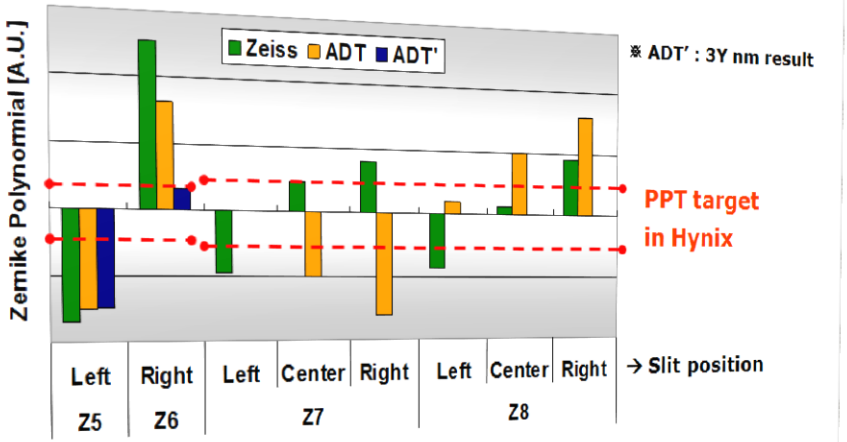
HP 100nm HP 90n

L2
L1

EUV Symposium (2009, Oct.)

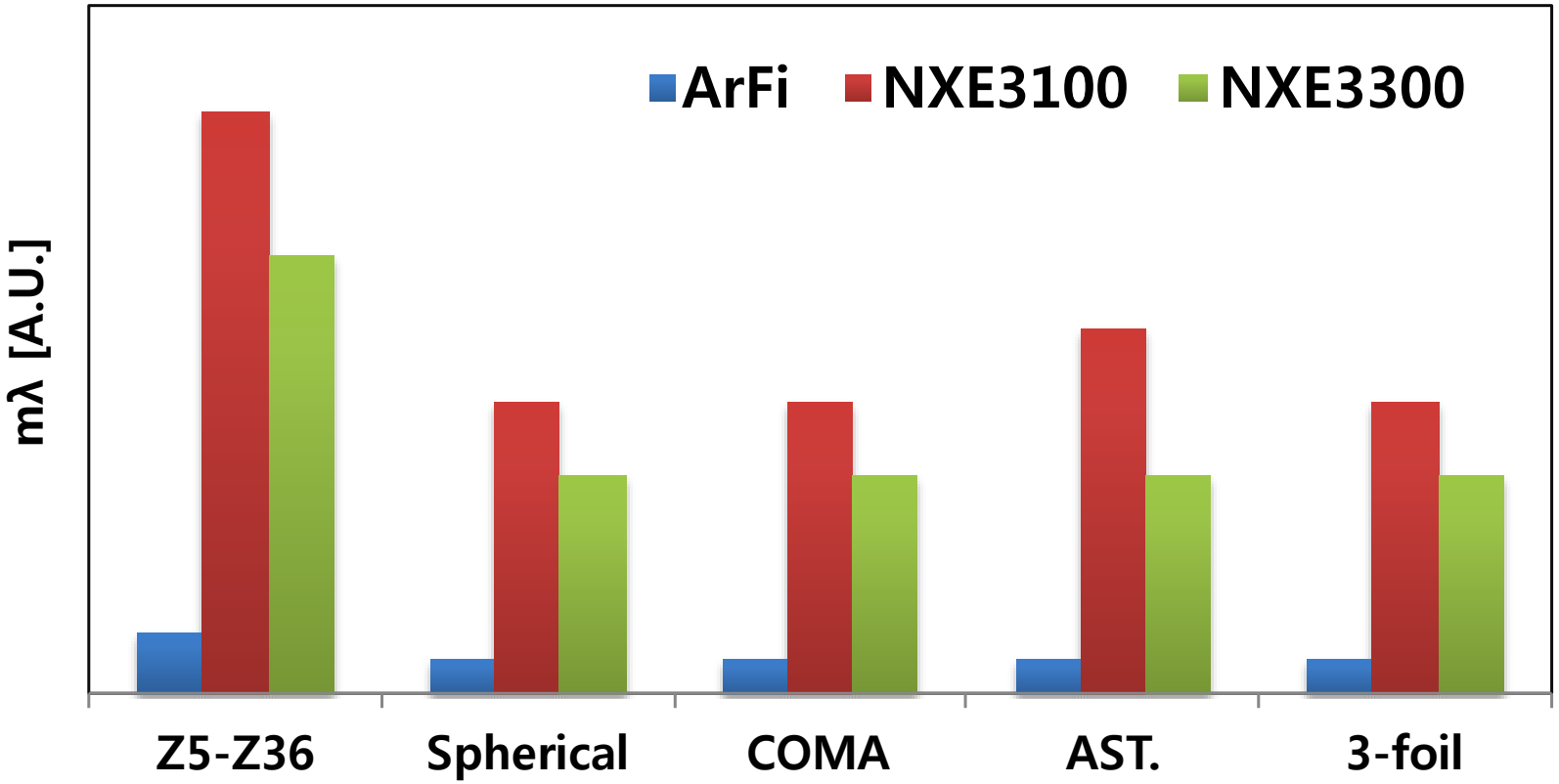
Status of ADT Aberration

- Trend of calculated aberration is similar to Zeiss result.
- Both results don't meet PPT target in hynix.



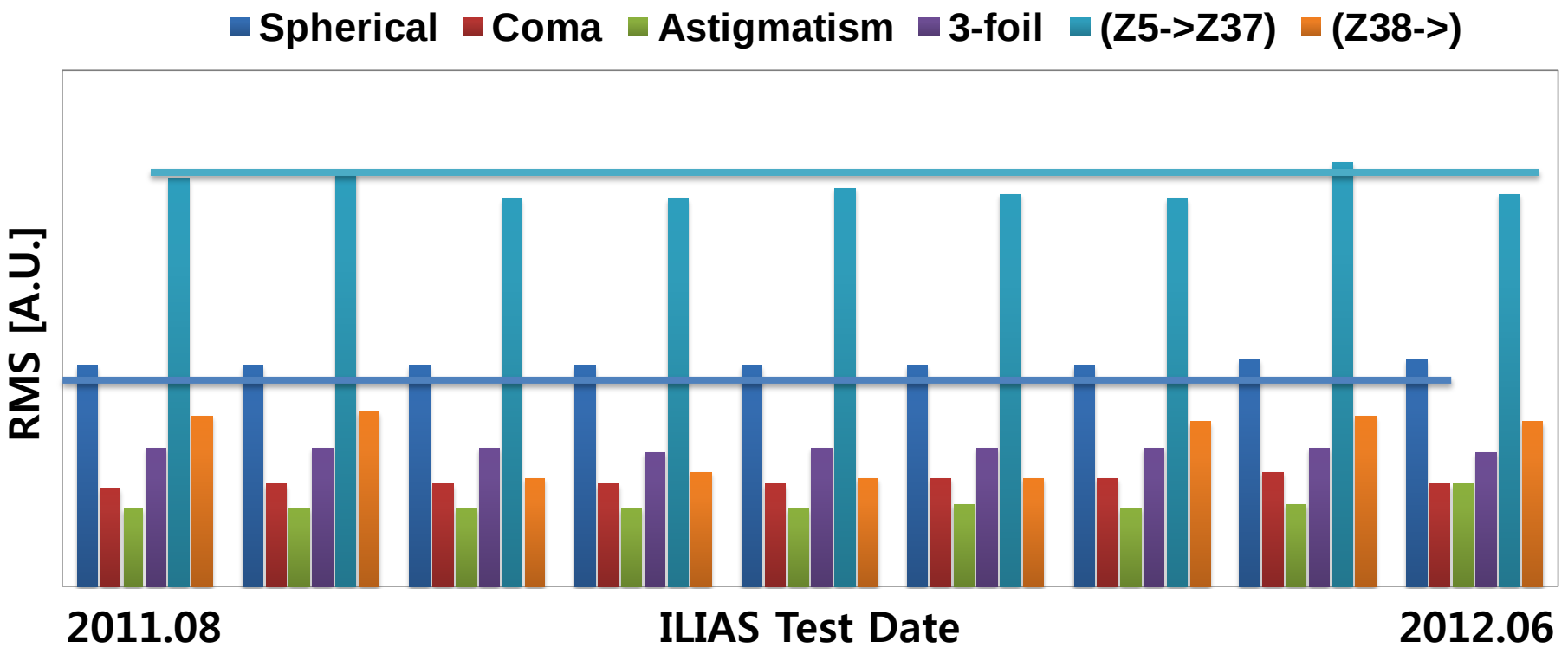
hynix

Aberration Spec in EUV Compared to 193nm



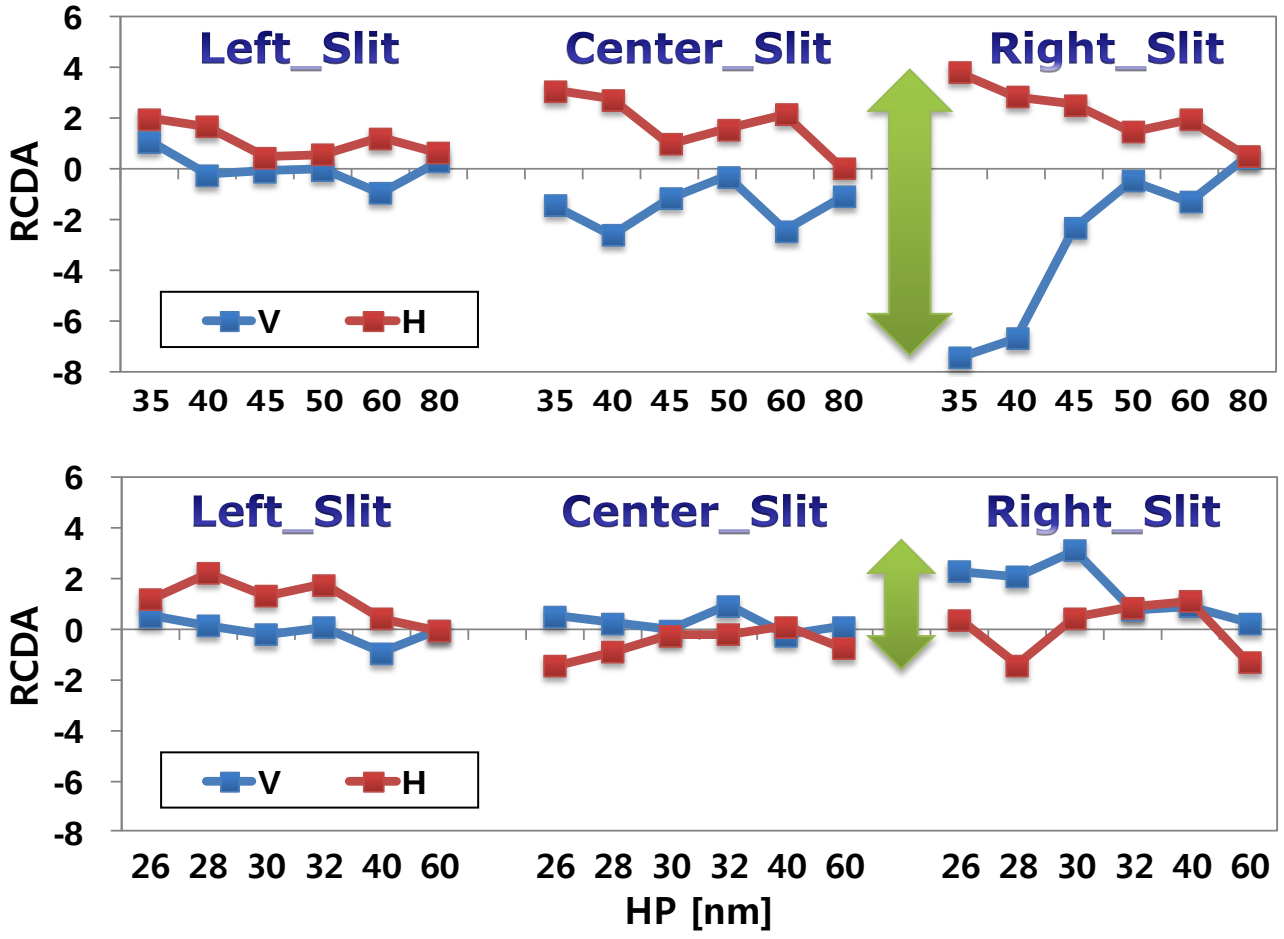
Aberration level of EUV is 10 times larger than ArFi

Aberration Trend



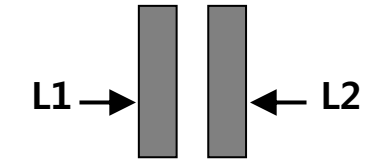
Aberration measured by ILIAS looks stable over time, while spherical and Z5~Z37 RMS are slightly over specification

ADT vs. NXE3100; CD Asymmetry



@ADT

@NXE3100



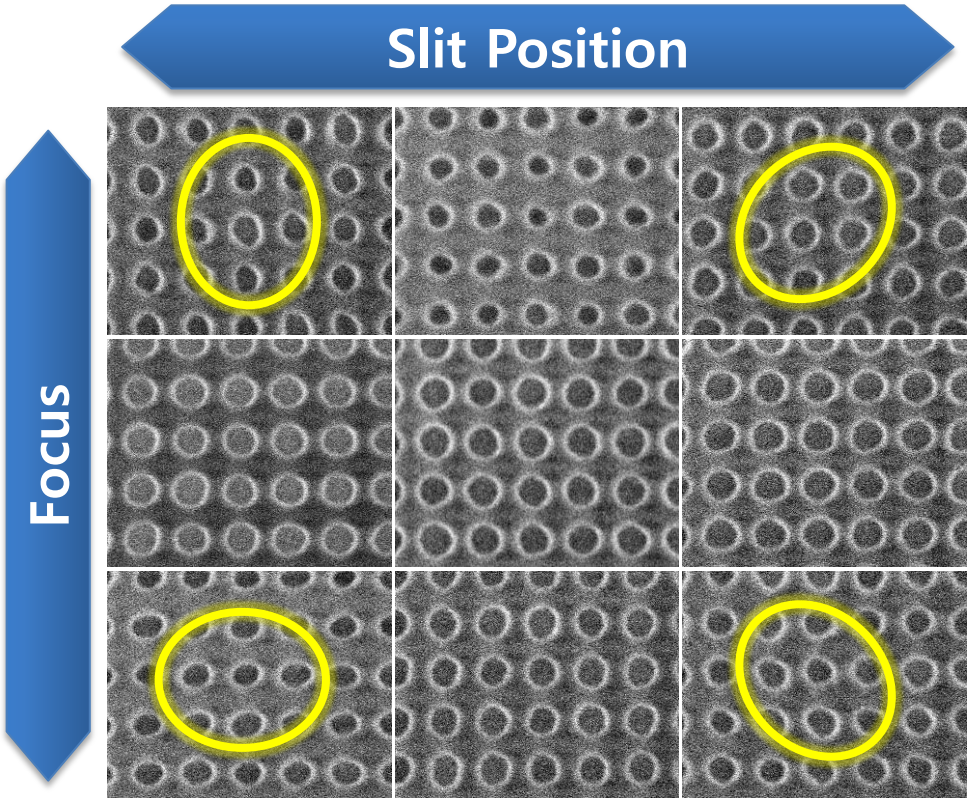
Line width asymmetry

RCDA : (L1-L2)/(L1+L2)

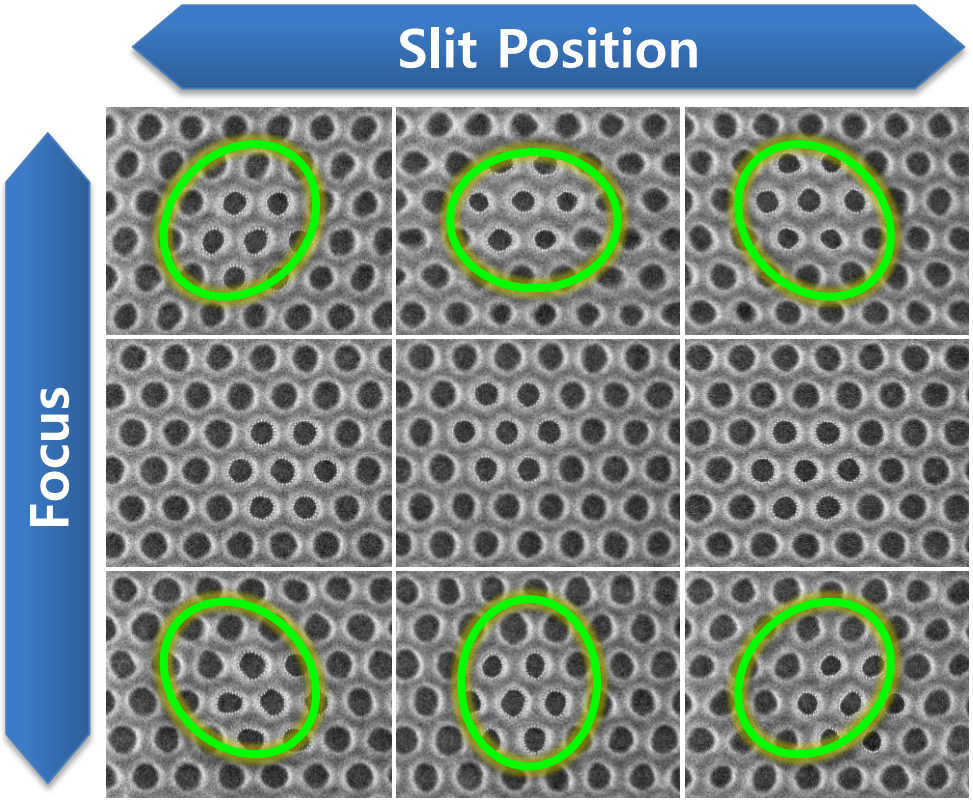
In spite of smaller pitch patterned at NXE3100, COMA effect reduced from ADT

IPD & Astigmatism

2Xnm DRAM @ADT

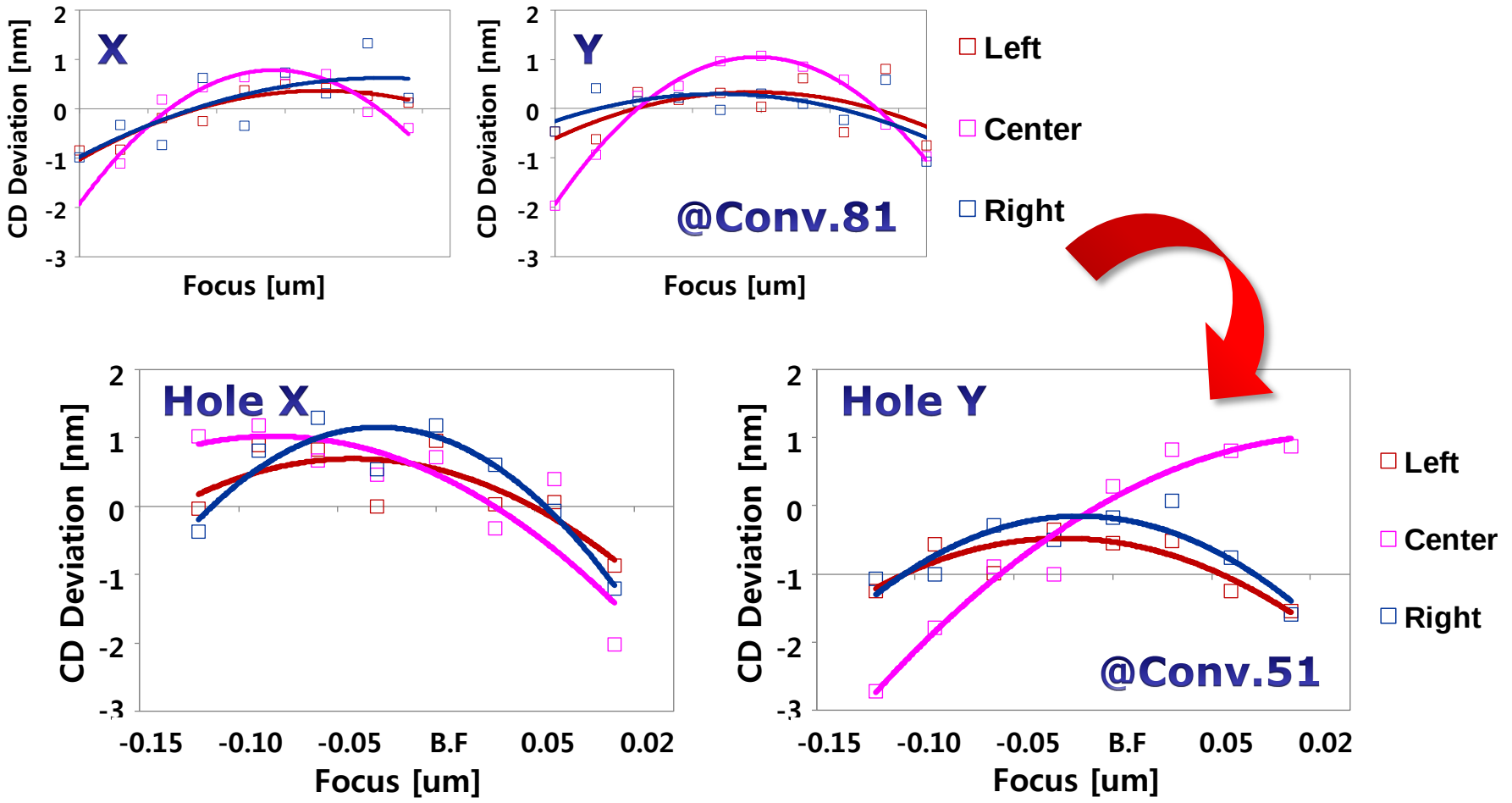


1Xnm DRAM @NXE3100



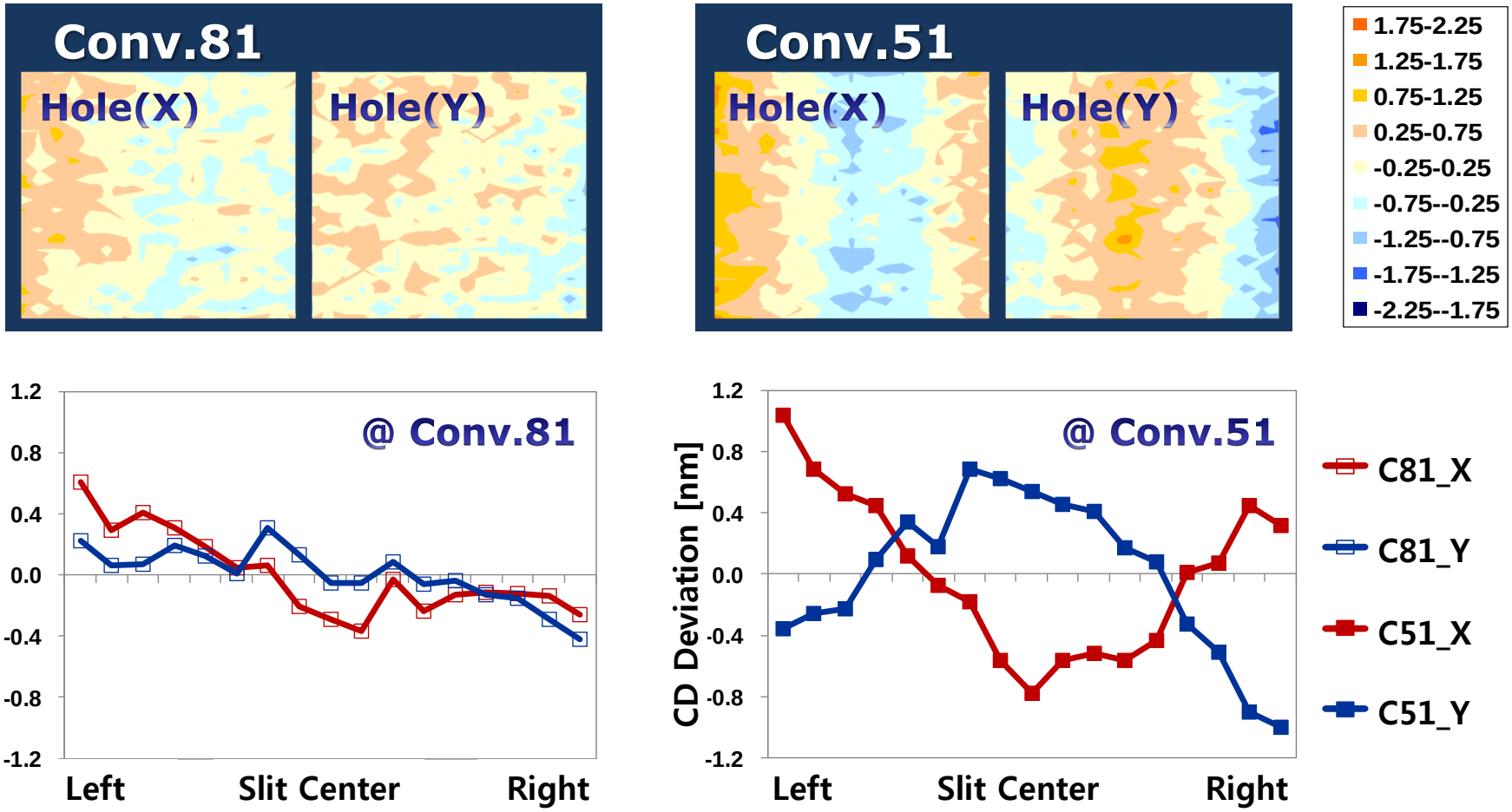
Contact hole profiles through focus showing strong astigmatism behavior in both ADT and NXE3100

Astigmatism & IPD on 1X DRAM in NXE3100



Astigmatism is very influential on patterning of 1Xnm node DRAM contact hole especially small sigma illumination case

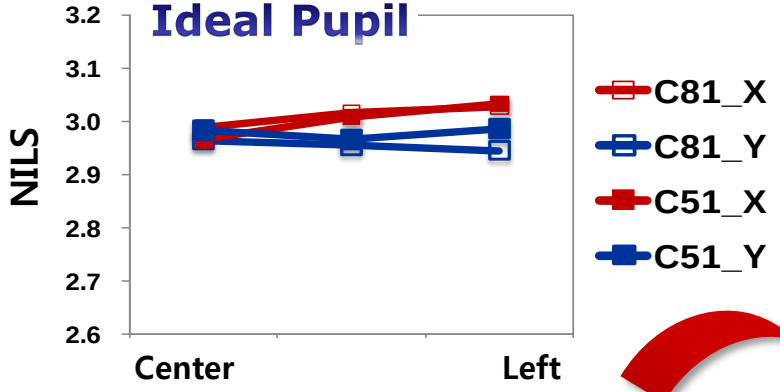
Intra-field CD Uniformity

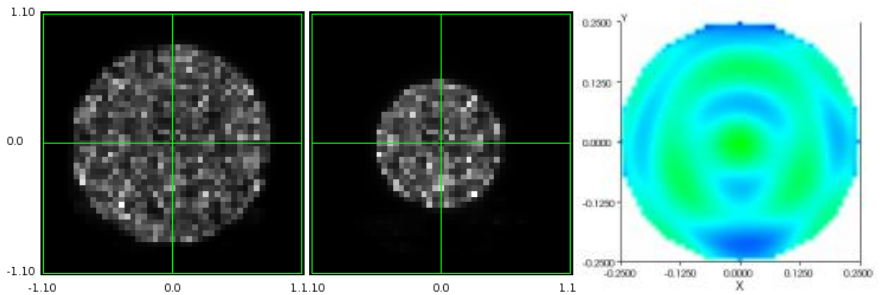


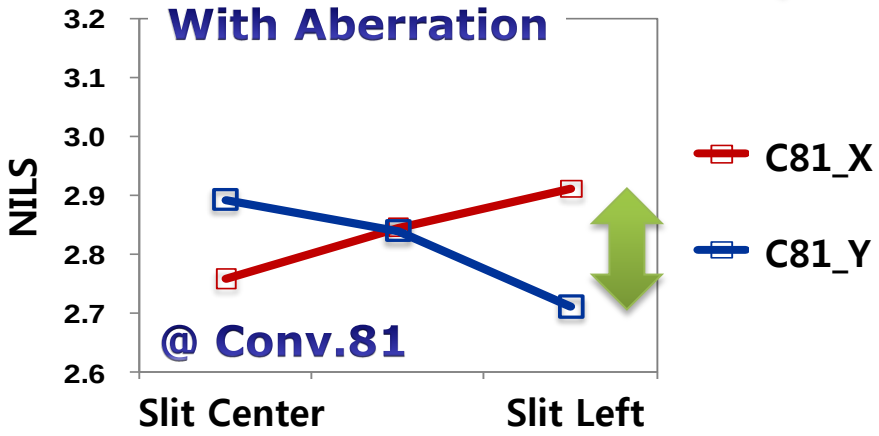
X-Y CD bias of 1Xnm DRAM contact hole pattern differs by illumination mode

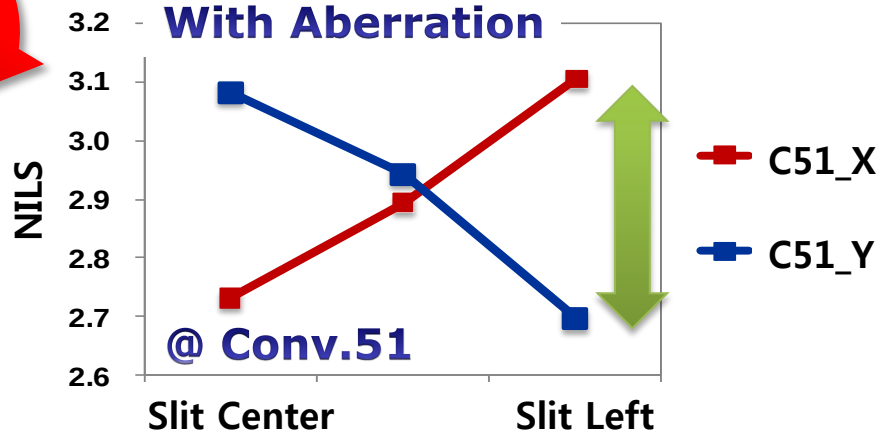
Simulation of Aberration

- Real illumination pupil and aberration are used for simulation.





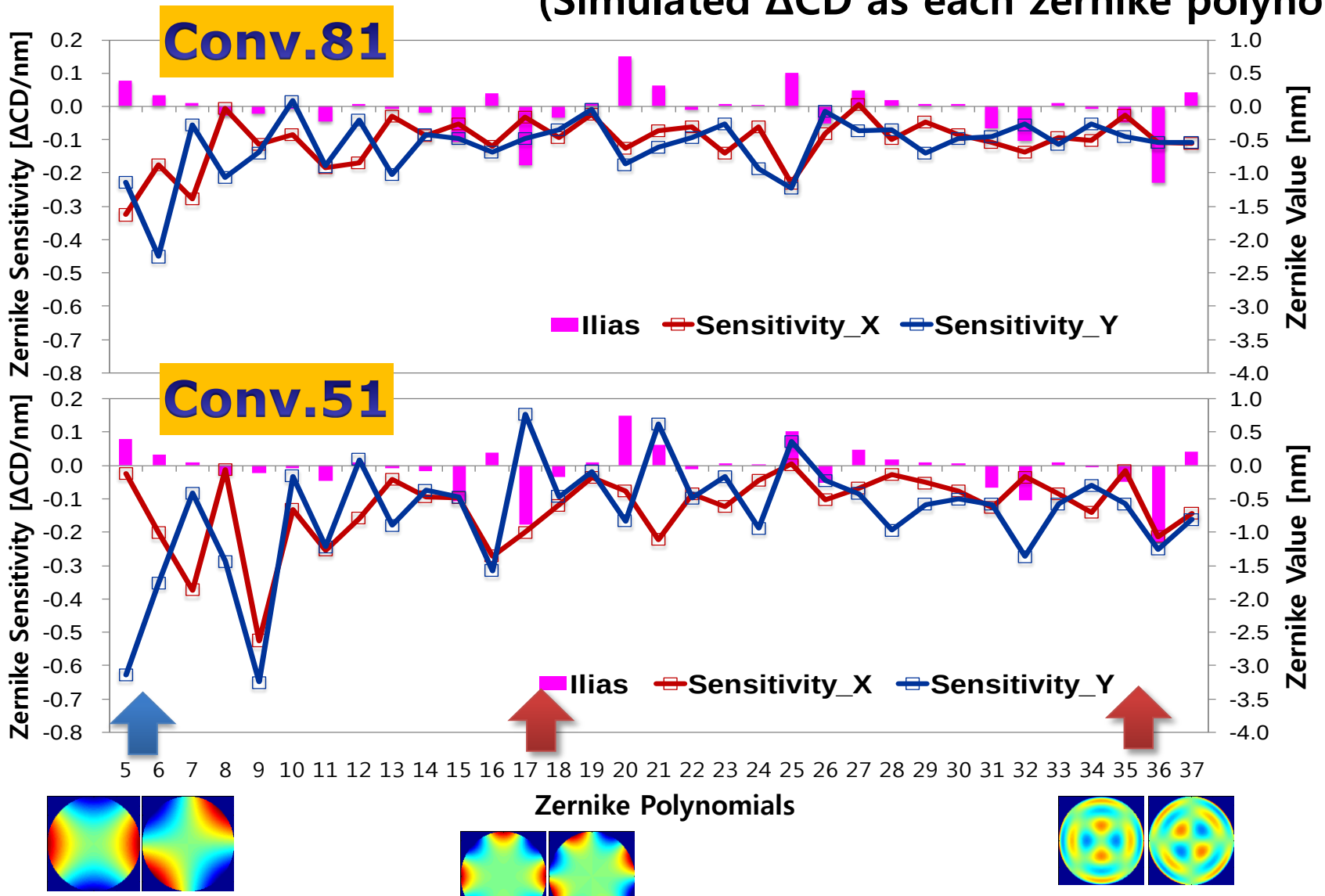




with aberration taken into account, XY difference of NILS along slit position intensified; more significant in small sigma

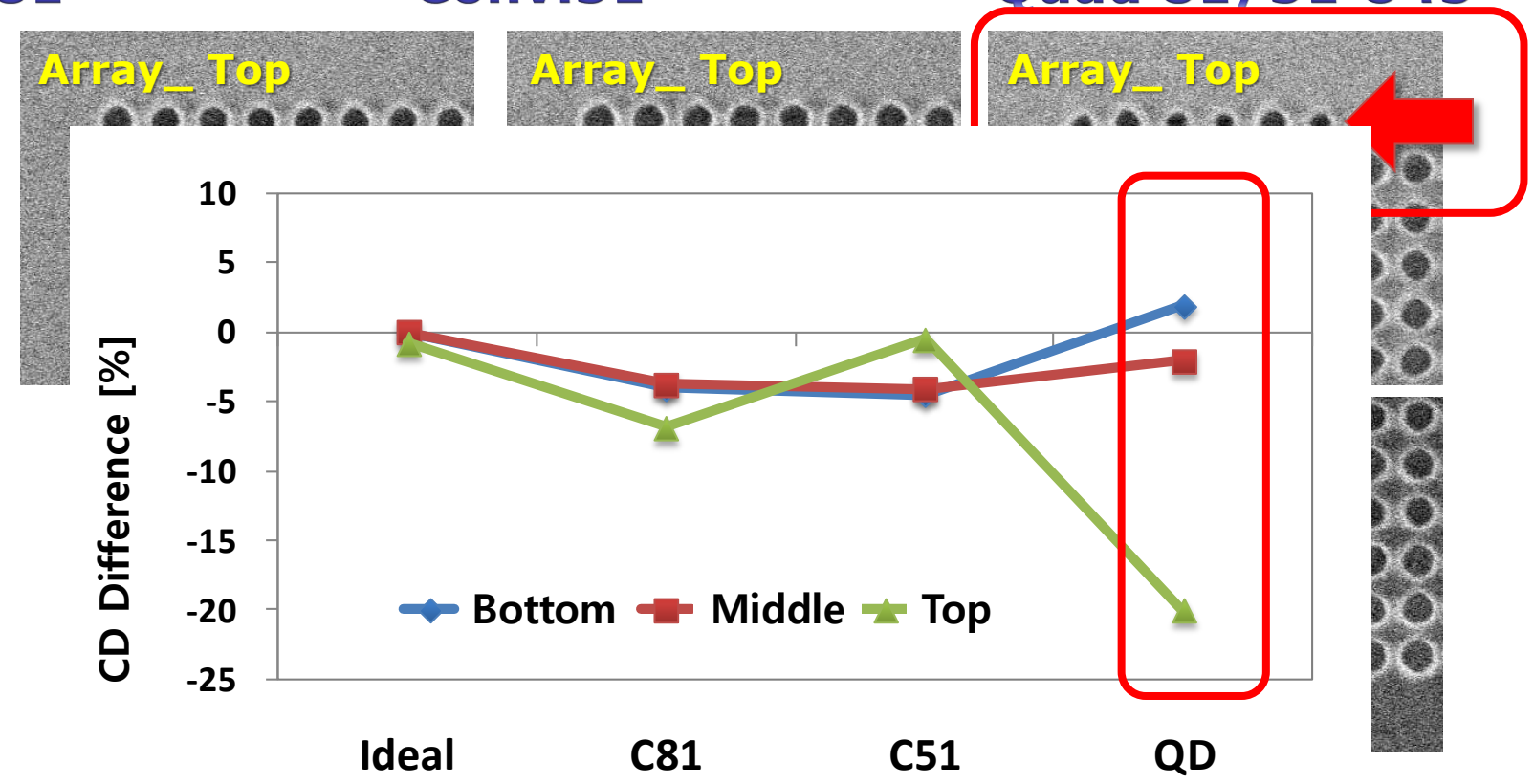
Zernike Sensitivity on 1Xnm CH

(Simulated ΔCD as each zernike polynomial)



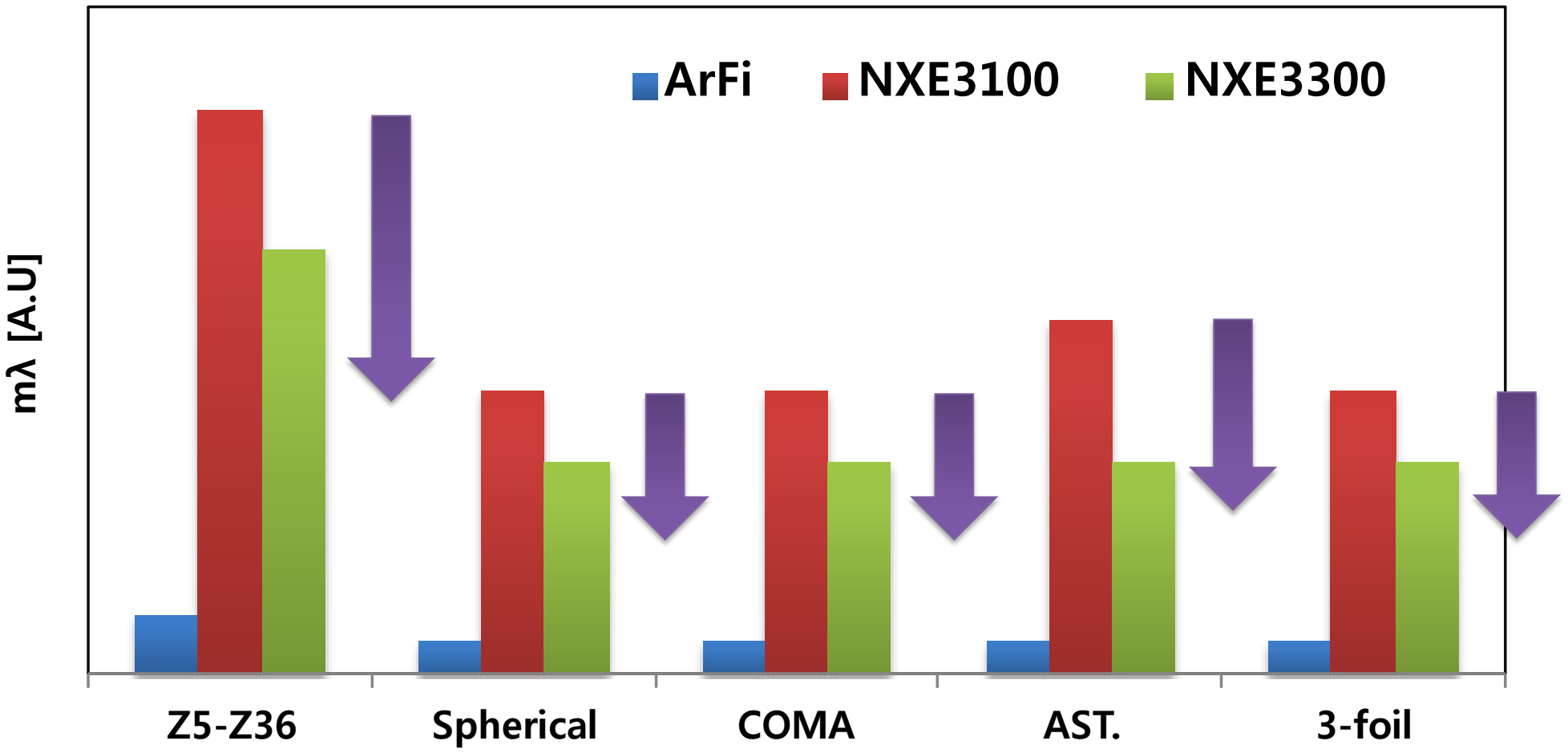
1Xnm node Contact Hole Patterning

Conv.81 Conv.51 Quad 81/51 O45



Illumination dependency of CD difference between top & bottom of array, which is expected well from simulation

Aberration Spec in EUV



Current aberration performance of NXE3100 is not enough for 1Xnm node patterning, need to be below half of current value

Summary

- ✓ **In spite of collector degradation, patterning performance kept stable for most of collector life time. Only seen difference when close to end of life.**
- ✓ **Aberration of NXE3100 remains stable after installation. Total RMS and spherical aberration are out of specification.**
- ✓ **Compared to ADT, the effect of COMA is reduced significantly in NXE3100, while the effect of Astigmatism still dominant at NXE3100 in patterning of 1Xnm contact holes.**
- ✓ **Aberration effect can be more sensitive dependent on illumination mode**
- ✓ **Aberration need to be improved for 1Xnm node patterning**

Thank You…