ahead of Change

EUV Symposium (2011, Oct.)

Process Overlay Controllability in EUV Lithography

Byounghoon Lee, Jun-Taek Park, Sunyoung Koo, Yoonsuk Hyun, Seokkyun Kim, Chang-Moon Lim, Donggyu Yim, Sungki Park

Hynix Semiconductor Inc.

hynix

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ITRS Overlay Roadmap

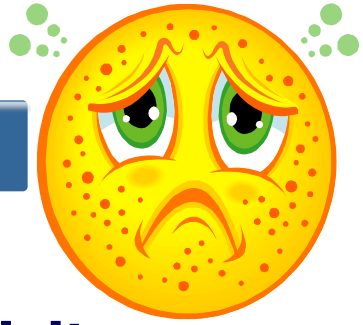
Year of Production	2012	2013	2014	2015	2016
DRAM ½ pitch(nm)	36	32	28	25	23
Overlay(nm)	7.1	**6.4**	**5.7**	**5.1**	4.5

From ITRS 2010

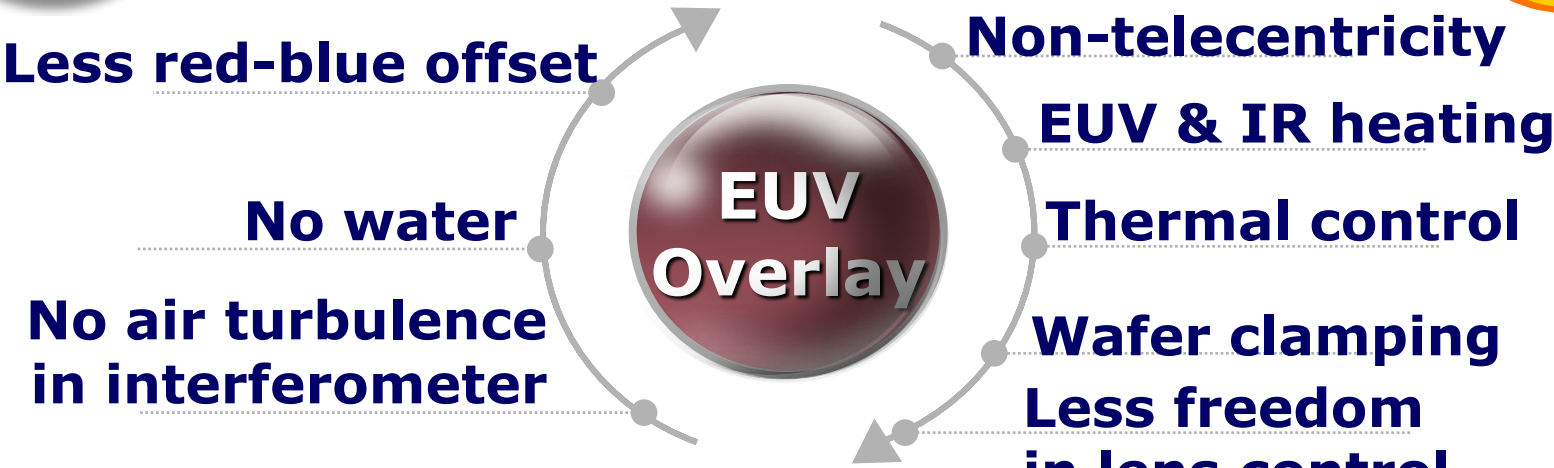
- EUV introduction from 32~25nm, 6 to 5nm overlay required
- High price of EUV HVM compels us to mix and match with ArF, hence EUV overlay gets more challenging

General Understanding

Positive



Negative

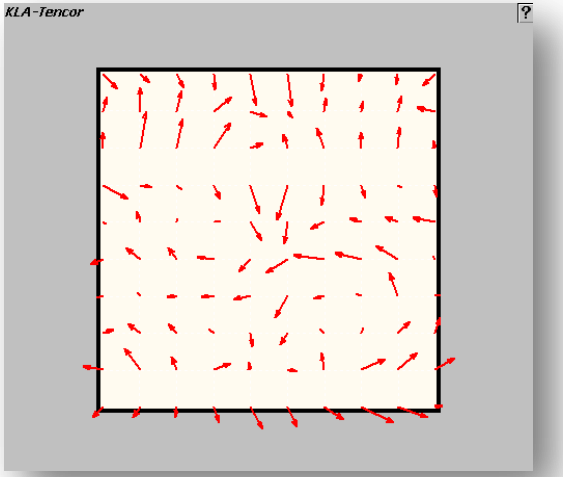


-Positive and negative aspects of overlay challenge in EUVL

What Main Factors in EUV Overlay

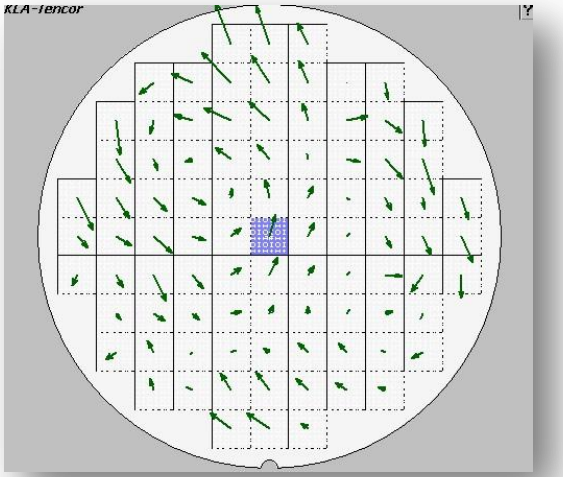
❒ Intra-Field Term

- Lens distortion and aberration
- Reticle flatness induced shift
- Reticle registration error
- Reticle clamping reproducibility
- …



❒ Inter-Field Grid Term

- Wafer clamping reproducibility
- Grid matching between tools (MMO)
- Machine stability
- Process effect
- …



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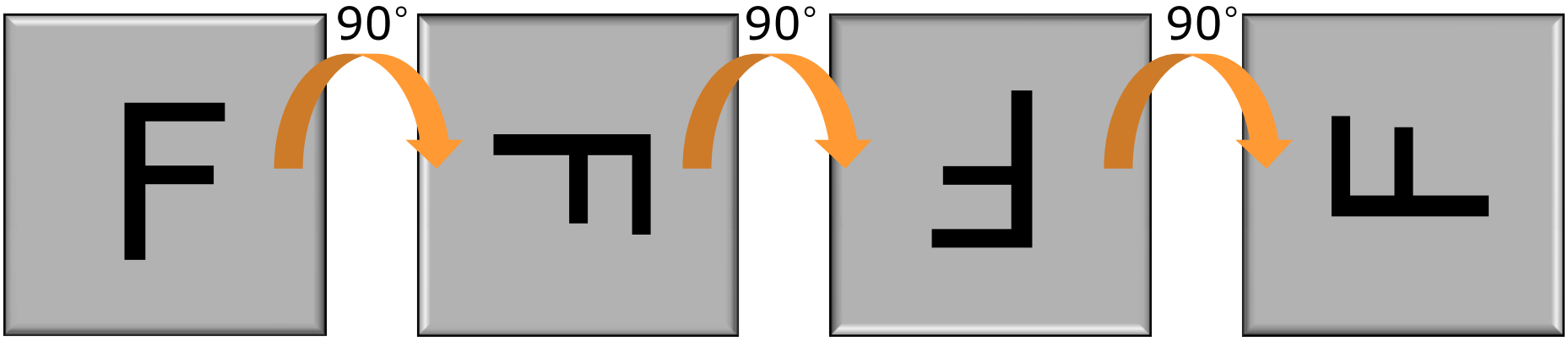
Rotatable Mask Experiment

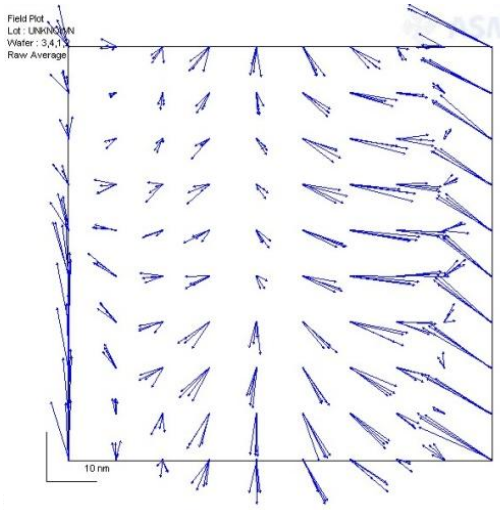


Field dependent Term
= Aberration+ Stage …

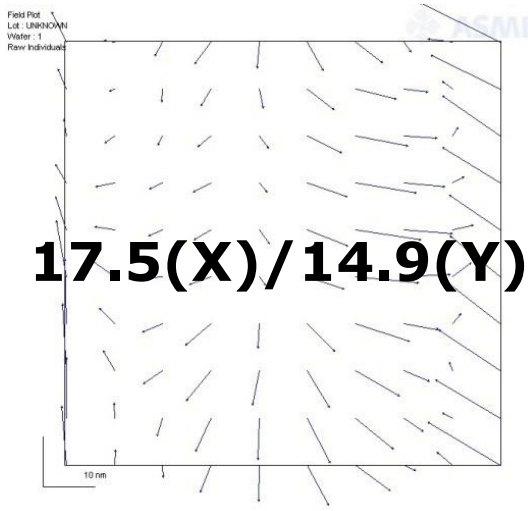
Mask dependent Term
= Registration + Flatness

Field Dependent Term; ADT vs. PPT

Mask A @ ADT

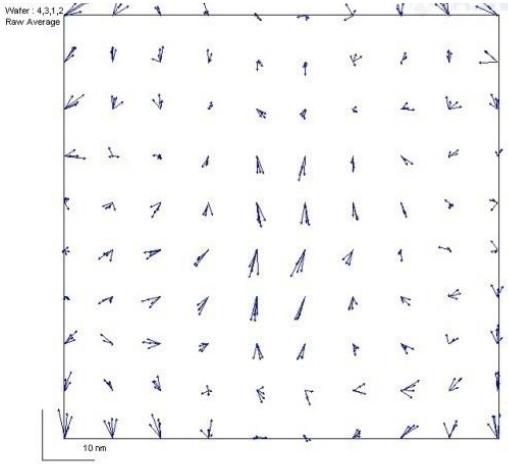


Ave.

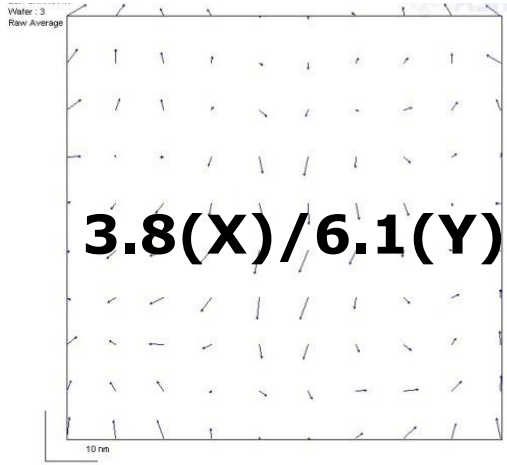


17.5(X)/14.9(Y)

Mask B @ PPT



Ave.

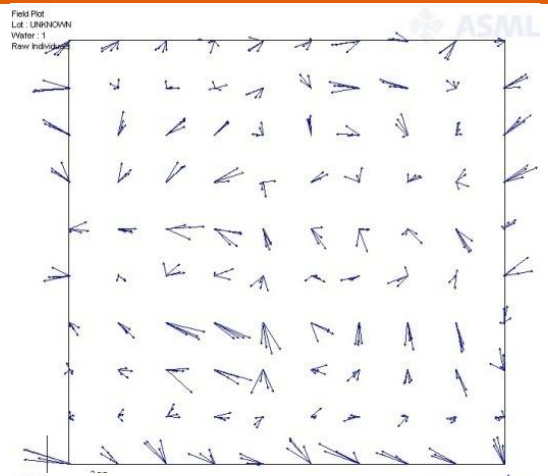


3.8(X)/6.1(Y)

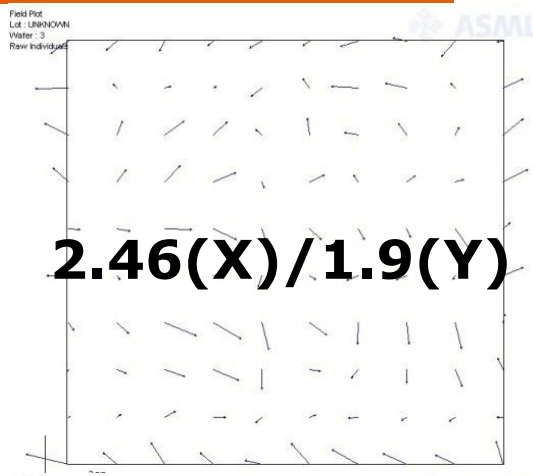
- Field dependent term is decreased in PPT tool because of significant improvement in lens distortion

Mask Dependent Term

Mask A
@ ADT

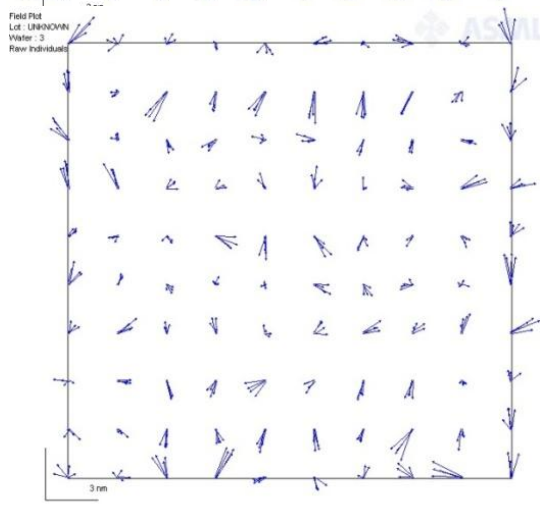


Ave.

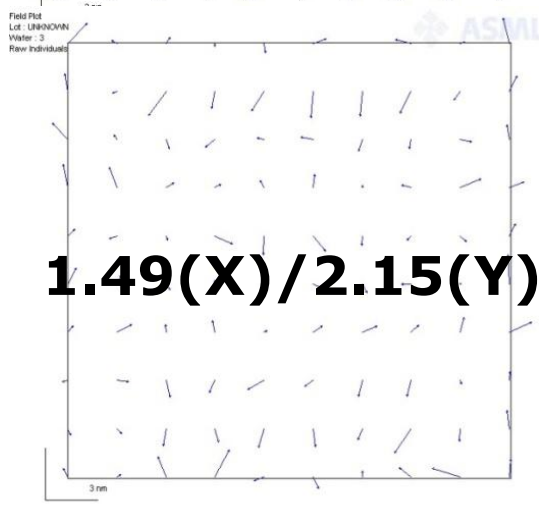


2.46(X)/1.9(Y)

Mask B
@ PPT



Ave.

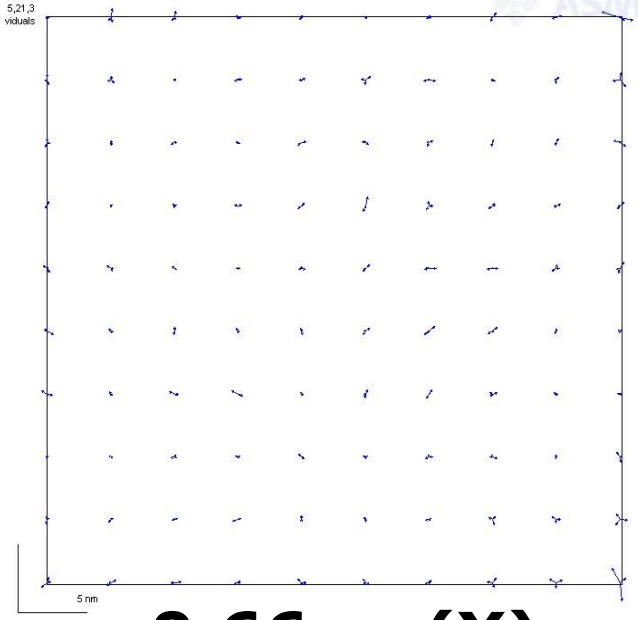


1.49(X)/2.15(Y)

- Mask term from flatness and registration
- Mask induced overlay error is less than 2.5nm

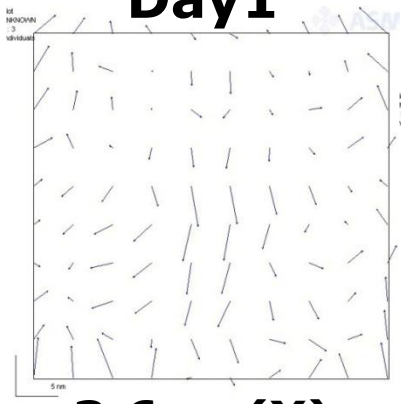
Reticle Clamping Reproducibility?

Reticle Clamping Repro



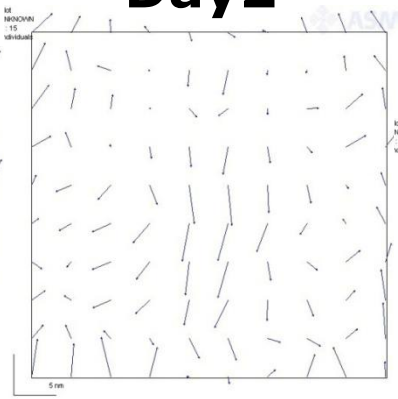
0.66nm(X)
0.62nm(Y)

Day1



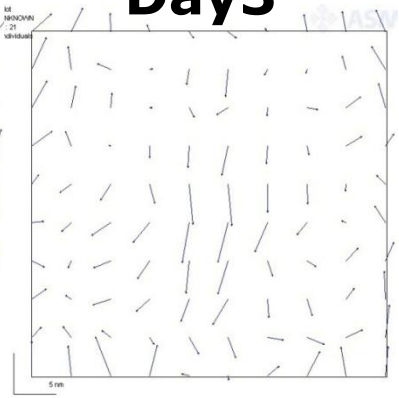
3.6nm(X)
6.5nm(Y)

Day2



3.3nm(X)
6.7nm(Y)

Day3



3.3nm(X)
6.9nm(Y)

- Reticle clamping reproducibility below 0.7nm, not substantial in EUV overlay control

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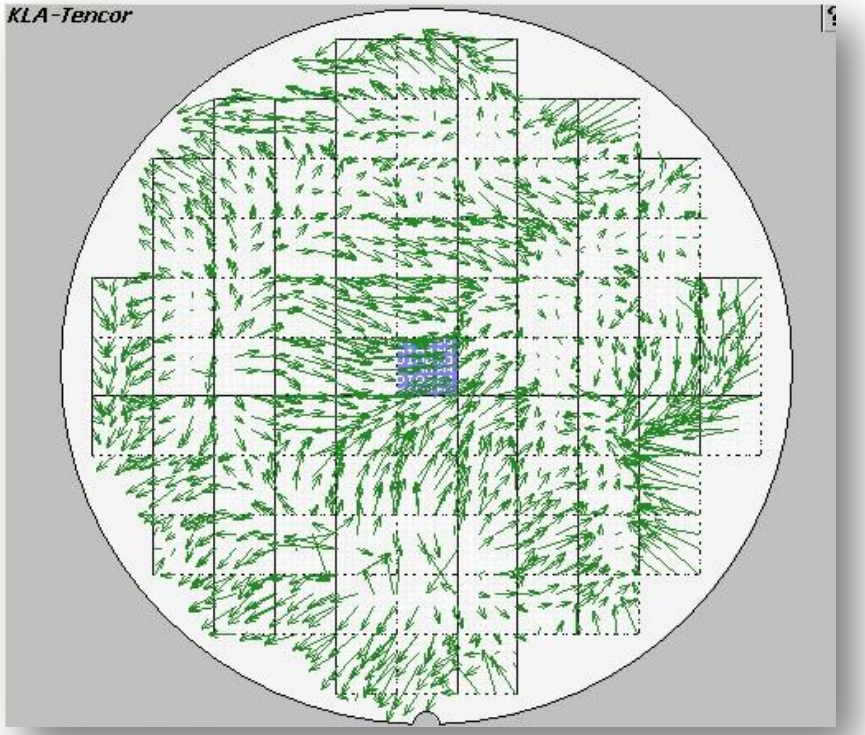
Why Large Overlay in SMO?

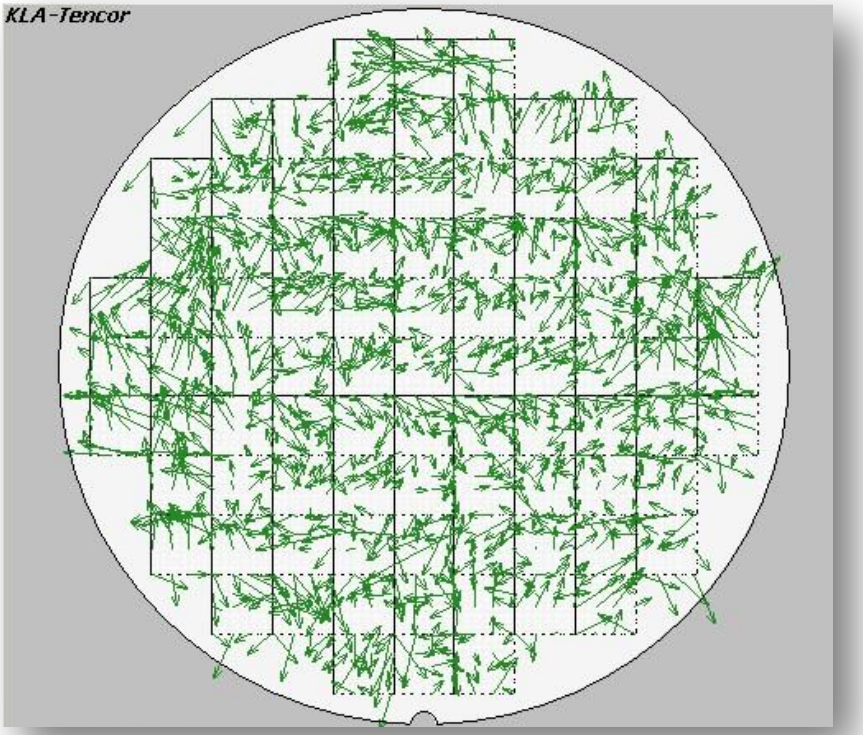
Back side polished wafer

SMO (1st : EUV/2nd : EUV)



Grid : 8.2(X)/6.2(Y)
Field : 1.3(X)/1(Y)

MMO (1st : ArFi/2nd : EUV)



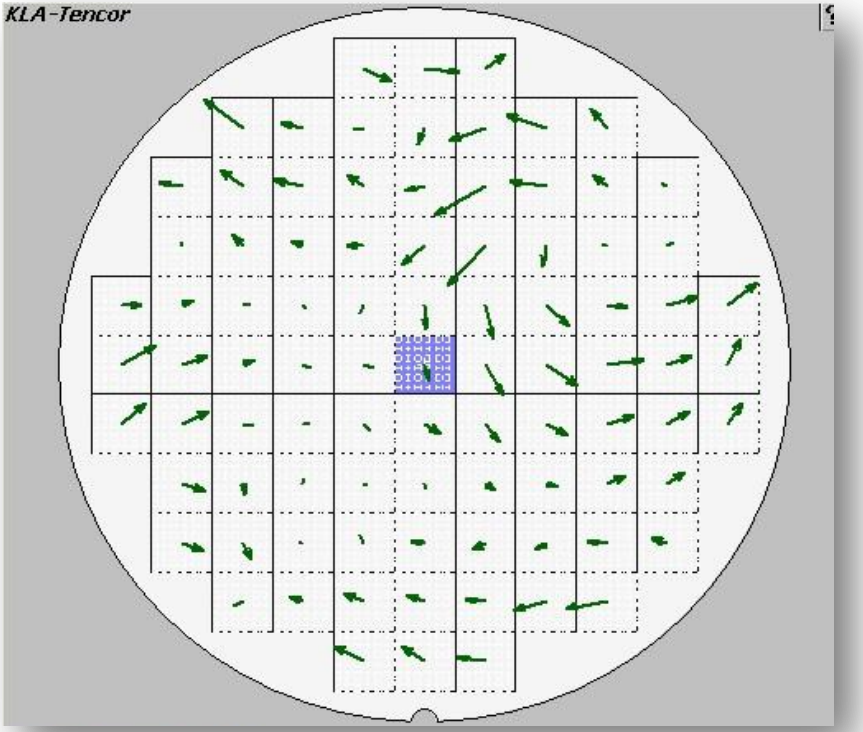
Grid : 8.2(X)/7.4(Y)
Field : 3.6(X)/5.2(Y)

- Grid terms are main factor of overlay control
- Grid term in SMO as large as MMO case

Wafer Clamping Effect

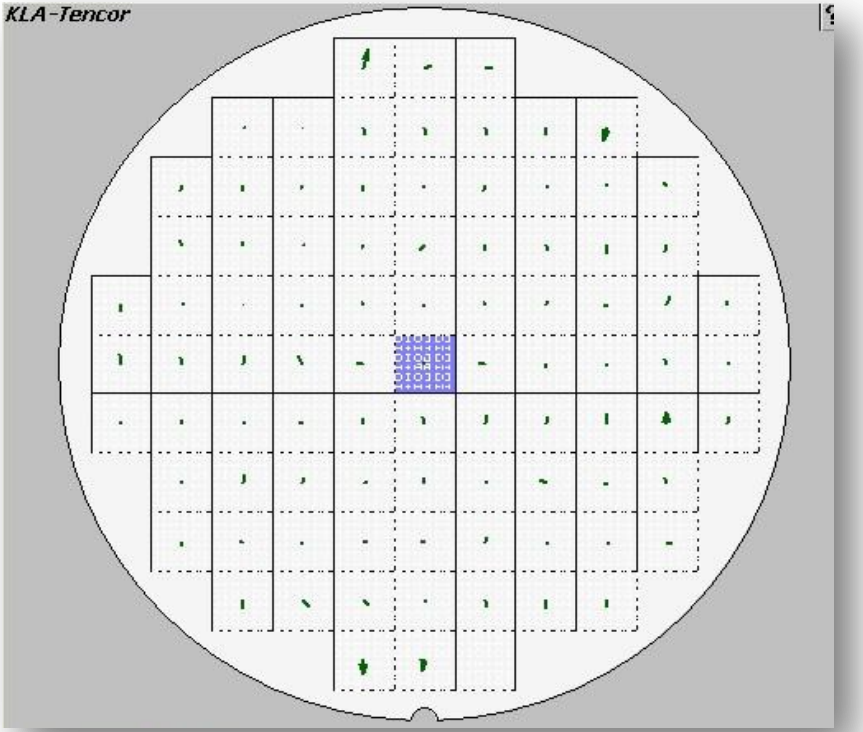
Double exposure w/ and w/o re-clamping of wafer

with re-clamping



4.2(X)/3.2(Y)

without re-clamping

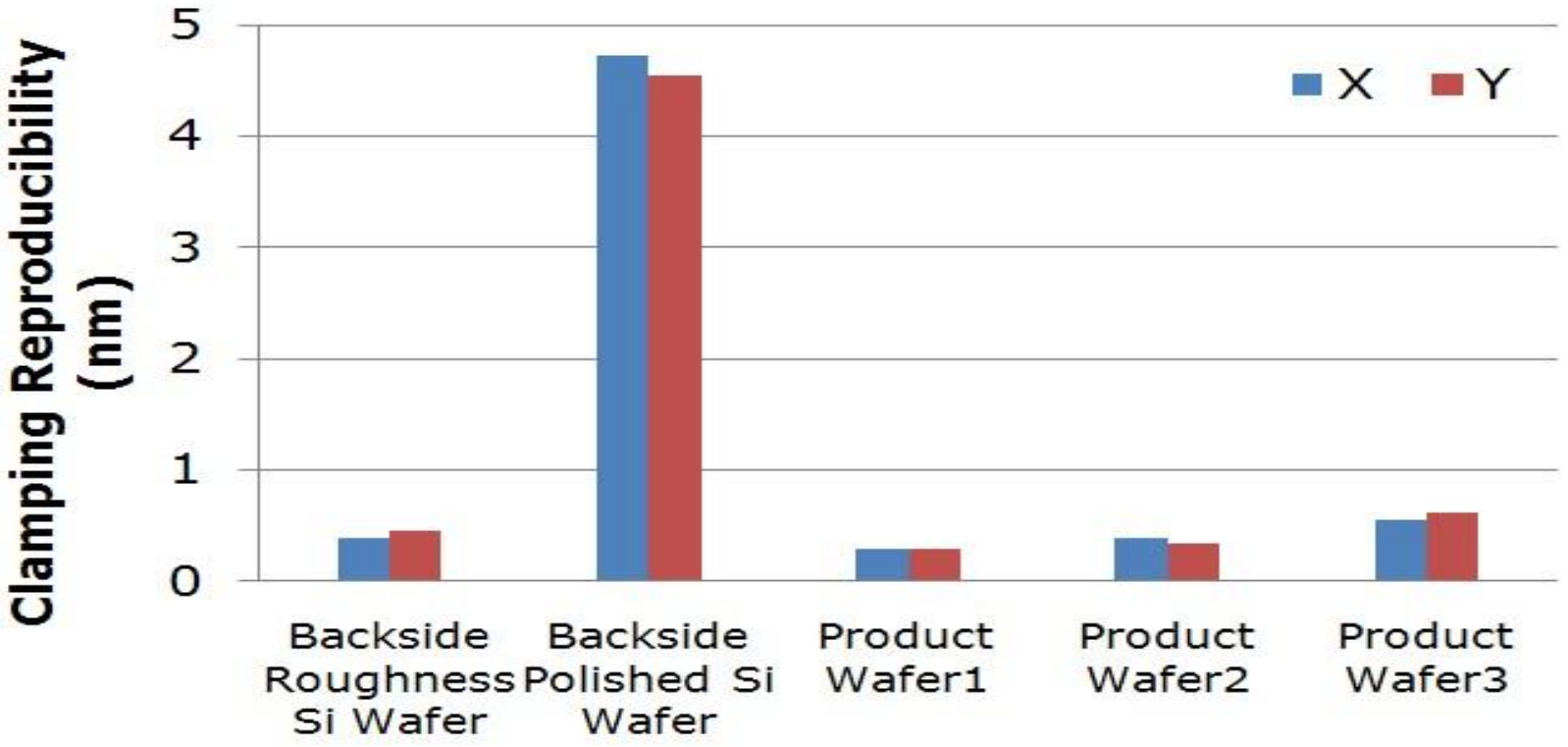


1.2(X)/1.7(Y)

- Wafer re-clamping makes substantial change in grid finger print because of change in chucking mechanism

Clamping Repro vs. Wafer Stacks

5 times measurement per wafer



- Wafer clamping repro is worse in backside polished Si wafer but quite acceptable in processed wafer with product stack, roughness of surface!!!

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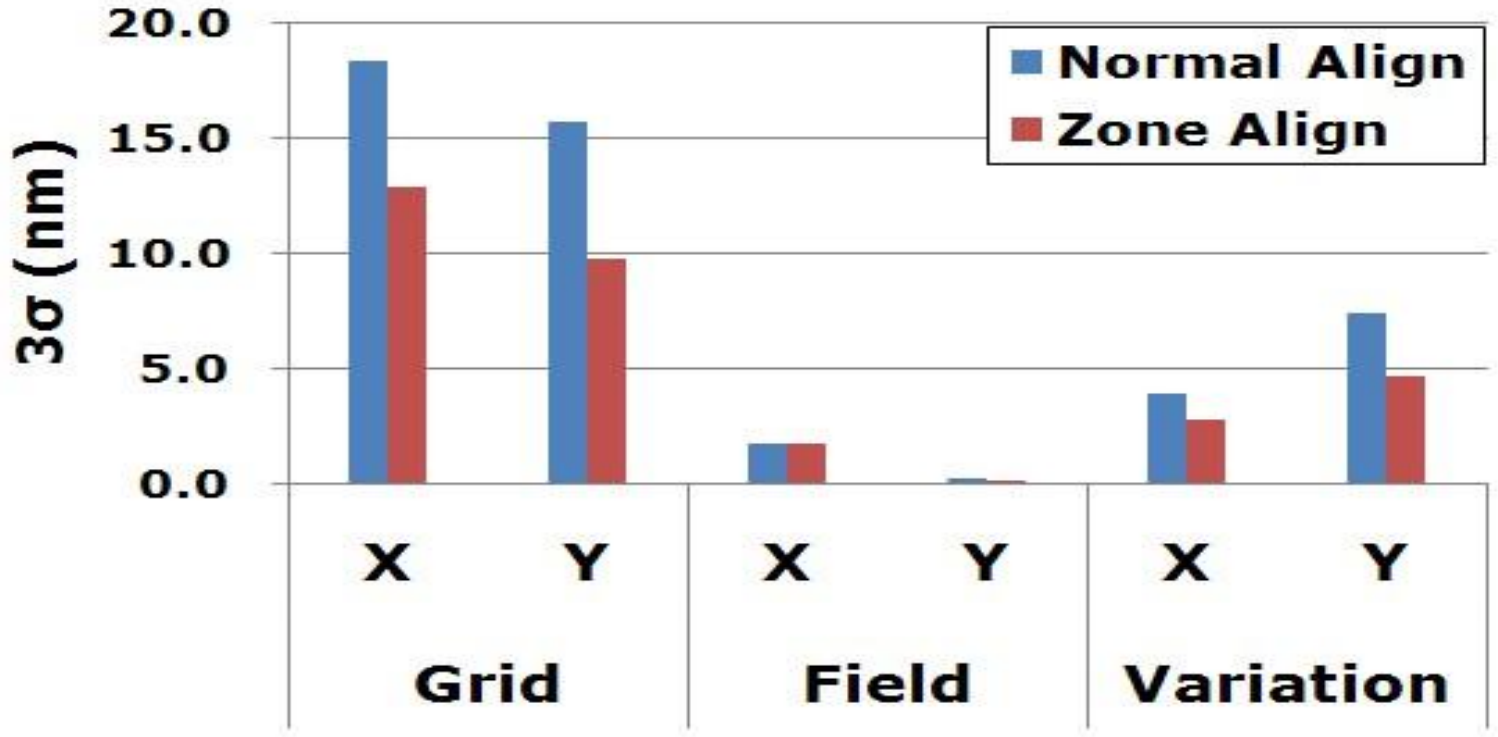
- **Product Overlay Control**
  - **Zone Align and Correction per Exposure**
  - **Product Overlay Controllability**
- Summary

Improvement by Zone Align

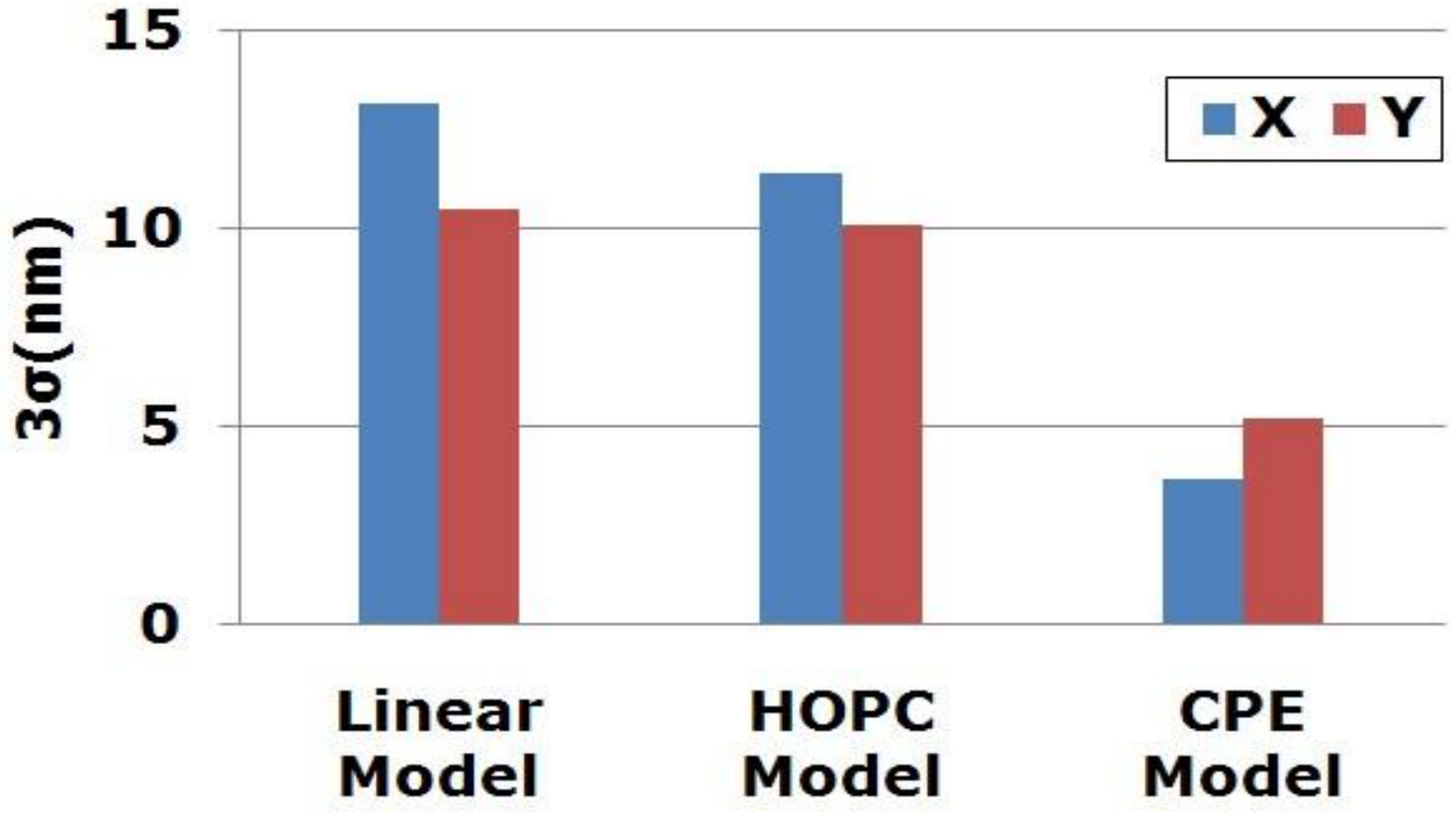
Overlay term analysis



- Grid term is dominant because of grid mismatch between EUV and ArFi tools
- Zone align improved wafer variation as well as grid residual error

Correction Per Exposure

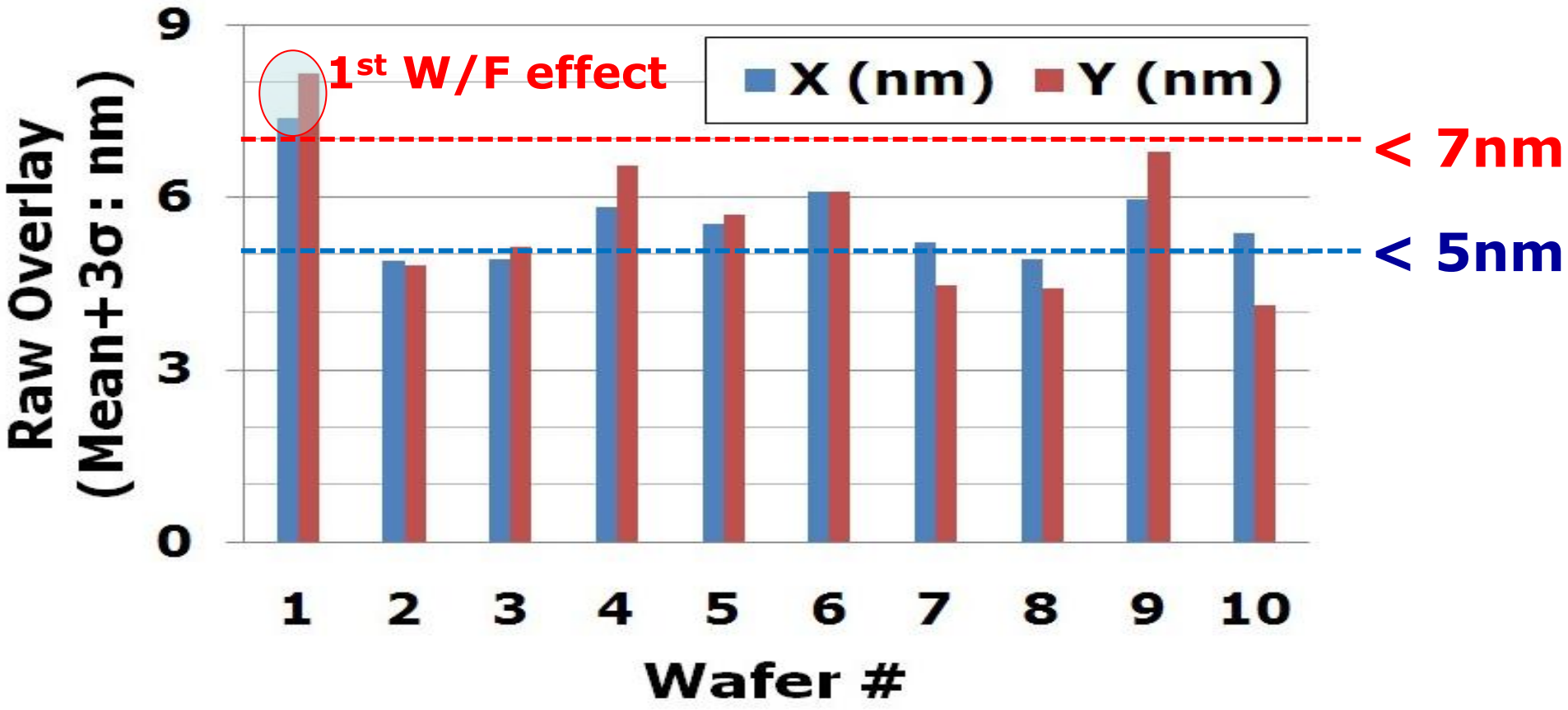
By Zone align



- Overlay improved significantly by CPE
- Grid matching with ArFi is very important

Matched Product Overlay Trend

10 wafer exposure



- Product overlay can be controlled below 7nm
- 1st wafer effect & wafer variation under investigation

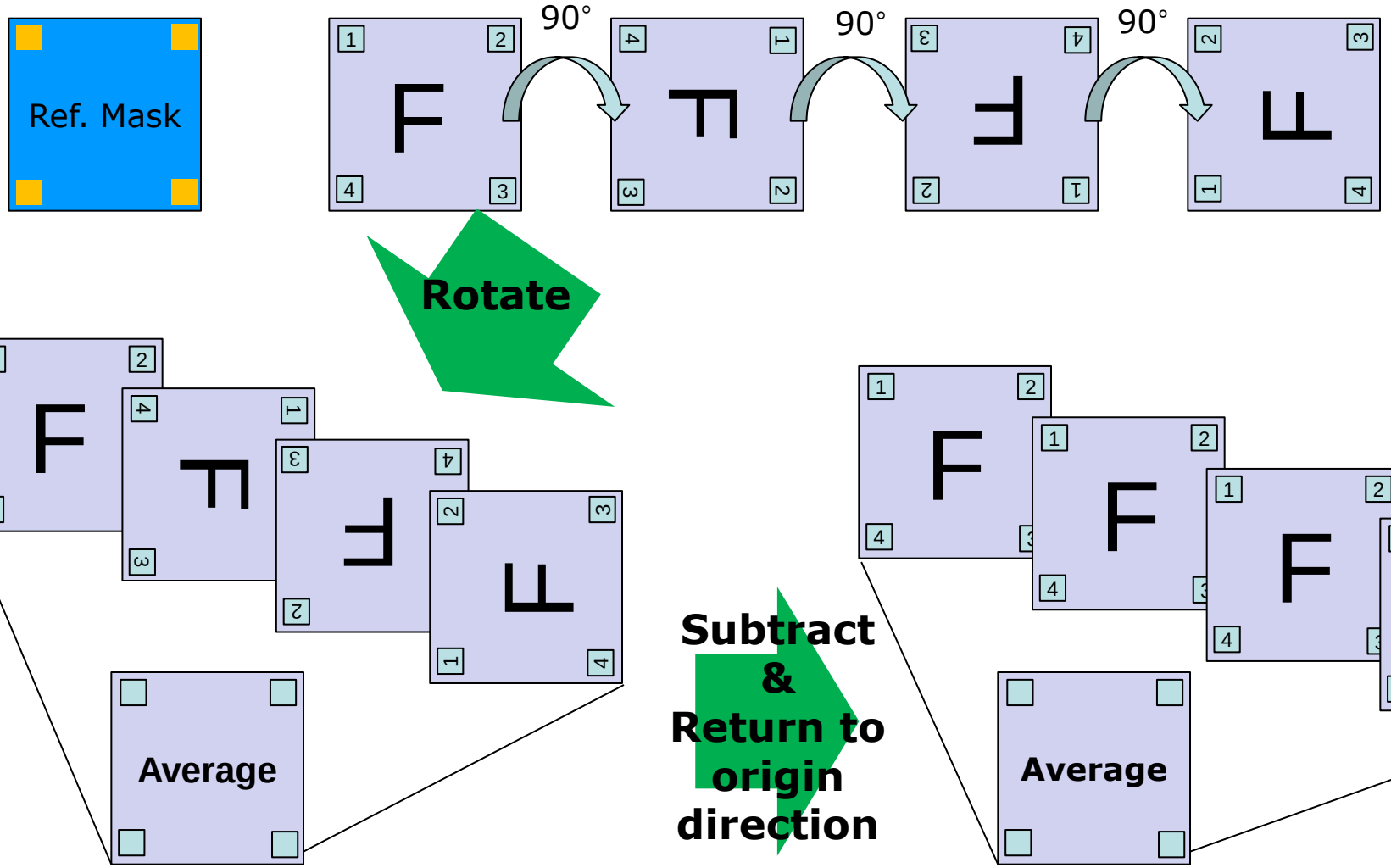
Summary

- ❒ Lens distortion improved significantly in PPT
- ❒ Mask dependent term is below 2.5nm that need to improved for 2Xnm DRAM
- ❒ Wafer clamping repro is worse in backside polished Si wafer, however good in product wafer
- ❒ Grid matching is very important in MMO
- ❒ On-product overlay achieved below 7nm by CPE and Zone align so far

Thank You....

Back-up

Rotatable Mask Experiment



≈ Field dependent Term
= Aberration+ Stage …

≈ Mask dependent Term
= registration + flatness