Overlay control by absolute coordinate adjustment and calibration method

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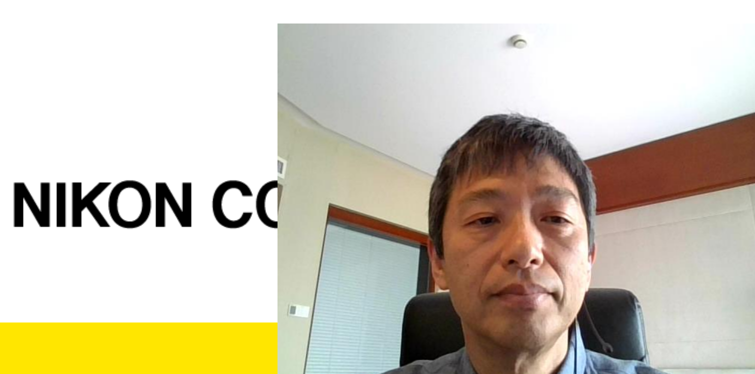
NIKON CO



Outline

- Challenges in correcting scanner grid error
- Solution of ideal grid correction
  - Absolute measurement method
  - 锐布 Litho Booster (LB)
  - Performance data
- Tool-to-tool Grid control method of LB (Zeroing)

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Challenges in overlay control

Requirement

Tighter On Product Overlay (OPO)

+

More complicated process

Error components

Reticle heat

Exposure

Lens heat

- Warped & distorted wafers
- Wafer heat

Wafer process

Thermal oxidization
Annealing
Etching
Ion implant
Thermal diffusion
CVD/PVD
CMP
…

Lot to lot
Wafer to wafer

Layer 1

Layer 2

Layer n

OPO → High order lot to lot / wafer to wafer adjustment are required ↔ THP loss

Process-Induced Distortion

Etching

Deposition

CMP

Bonding

New Structure

Process-induced high order grid distortion is generated

Traditional overlay feedback correction

Conventional Scheme

Host Computer
(APC)

Overlay
Feed-back

Scanner

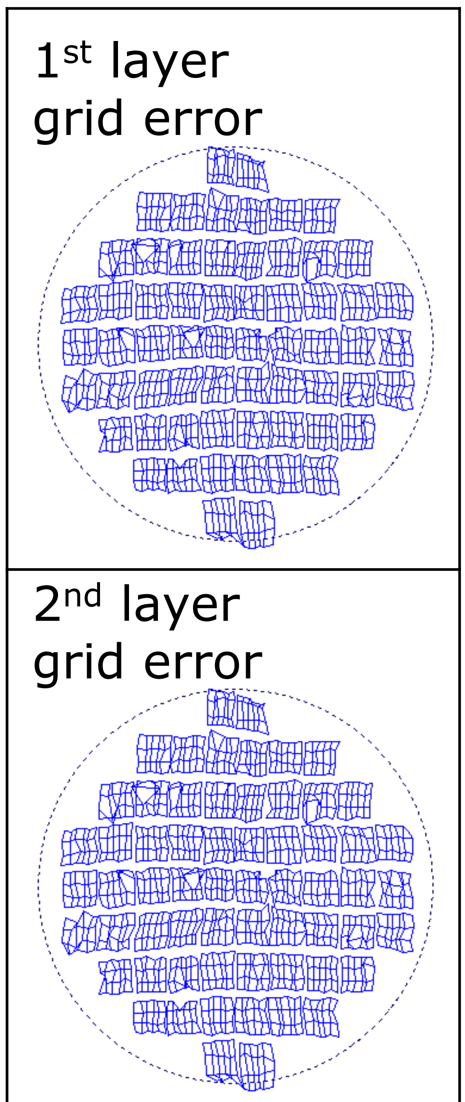
Coater

Developer

Sample
wafers

Overlay
Metrology

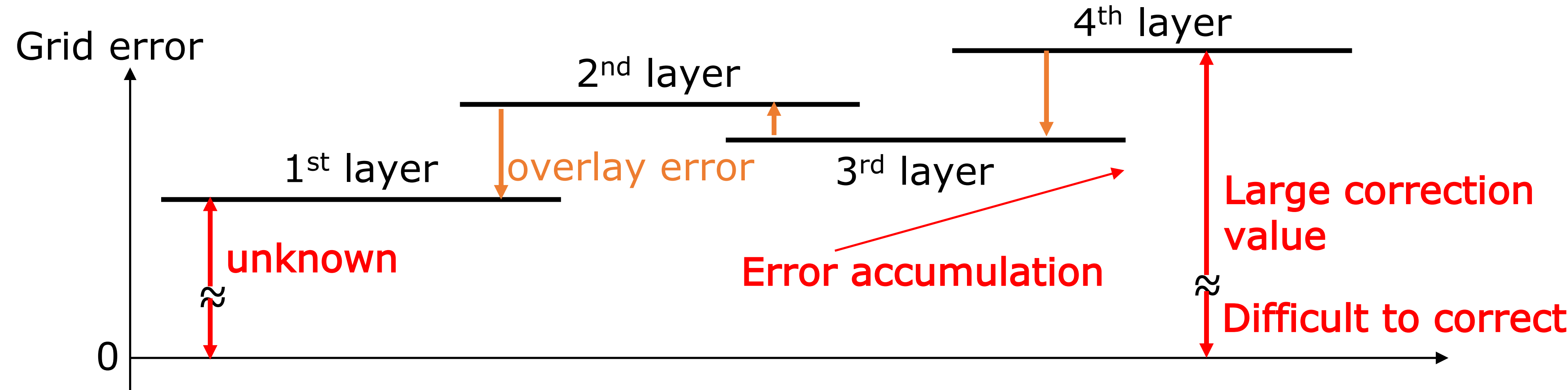
Wafer
Process

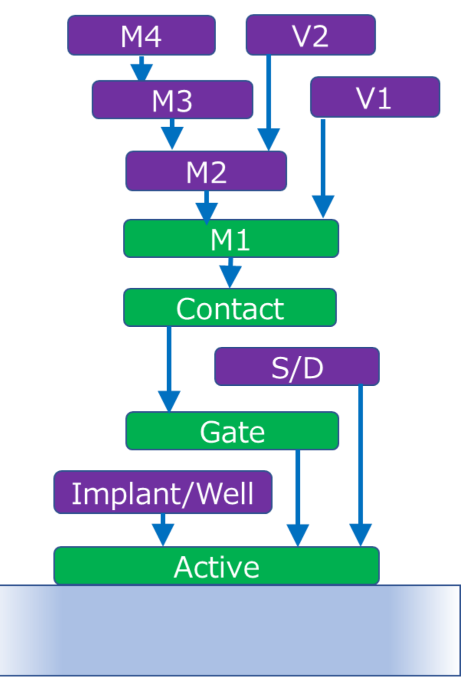


Fed back from overlay

Matched to 1st layer's distorted fingerprint

Traditional overlay relative correction





Overlay error is apparently small, but amount of correction value is large and difficult to optimize

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Challenges in correcting scanner grid error

Method	Grid error of 1st layer	Grid error of 2nd layer
Traditional overlay feedback correction		Fed back from overlay Matched to 1st layer's distorted fingerprint
Ideal grid correction to the absolute coordinate	Direct correction	Direct correction

Advantages of ideal grid correction

Traditional overlay feedback correction

Grid error

4th layer

2nd layer

1st layer

overlay error

3rd layer

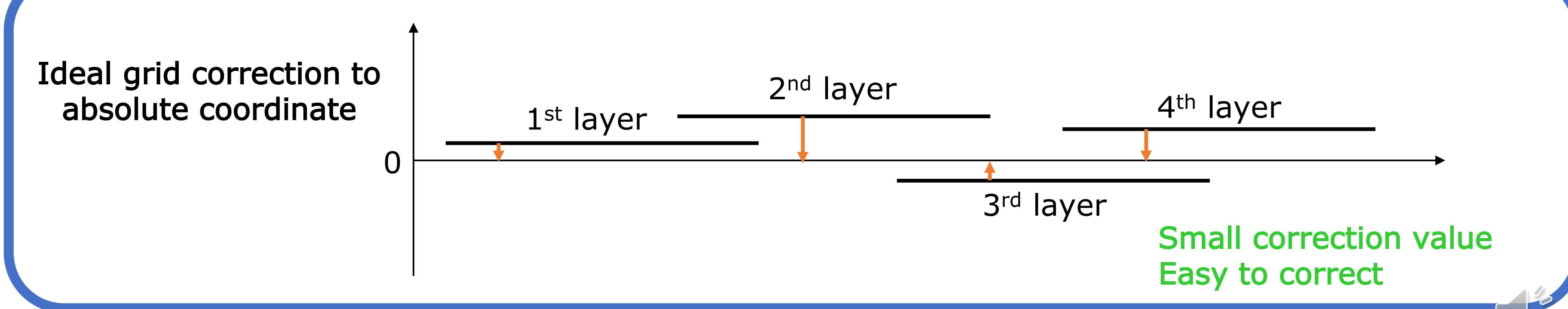
unknown

Error accumulation

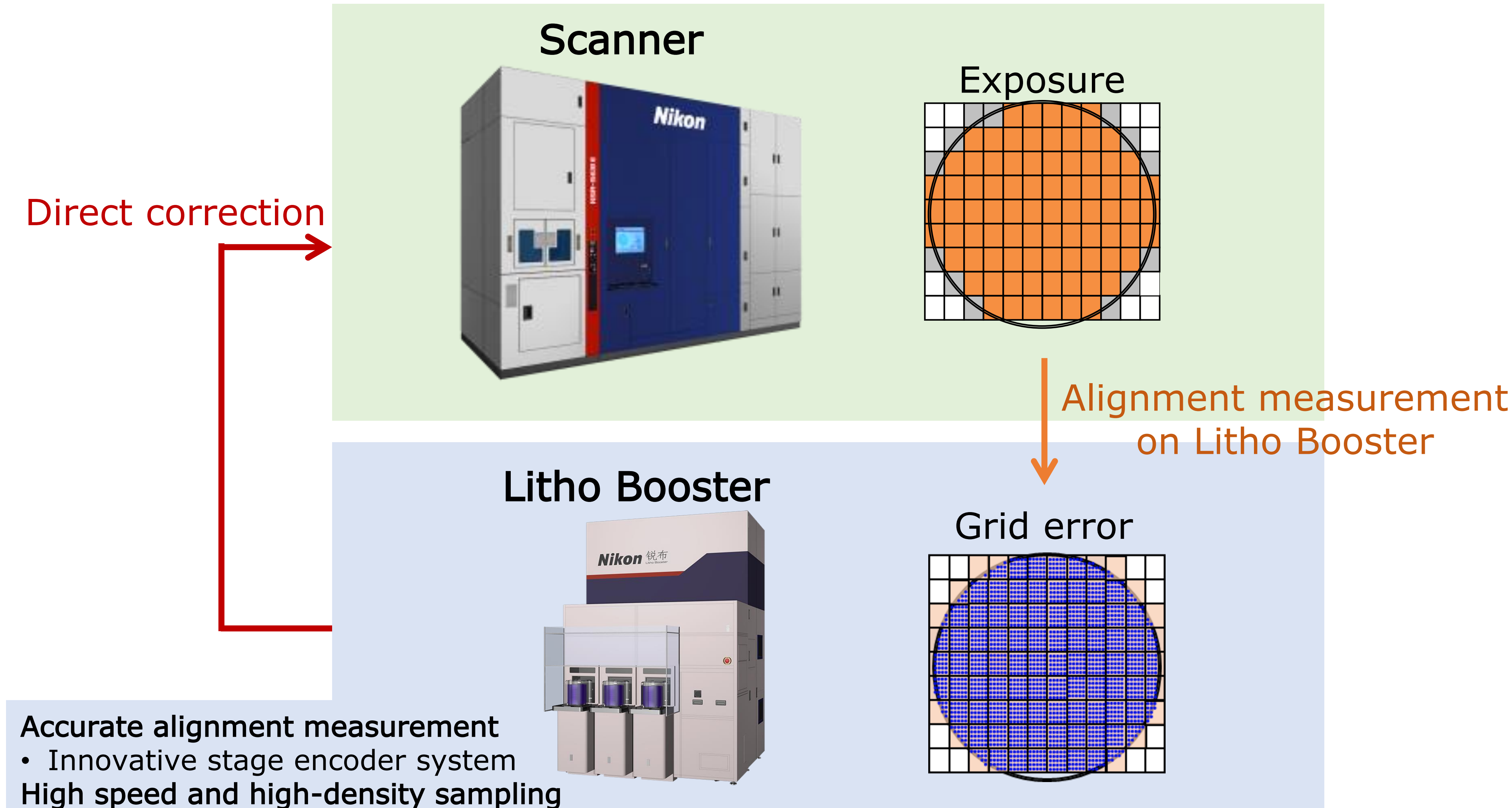
Large correction value

Difficult to correct

0



Standalone alignment metrology system : Litho Booster



Accurate alignment measurement
- Innovative stage encoder system

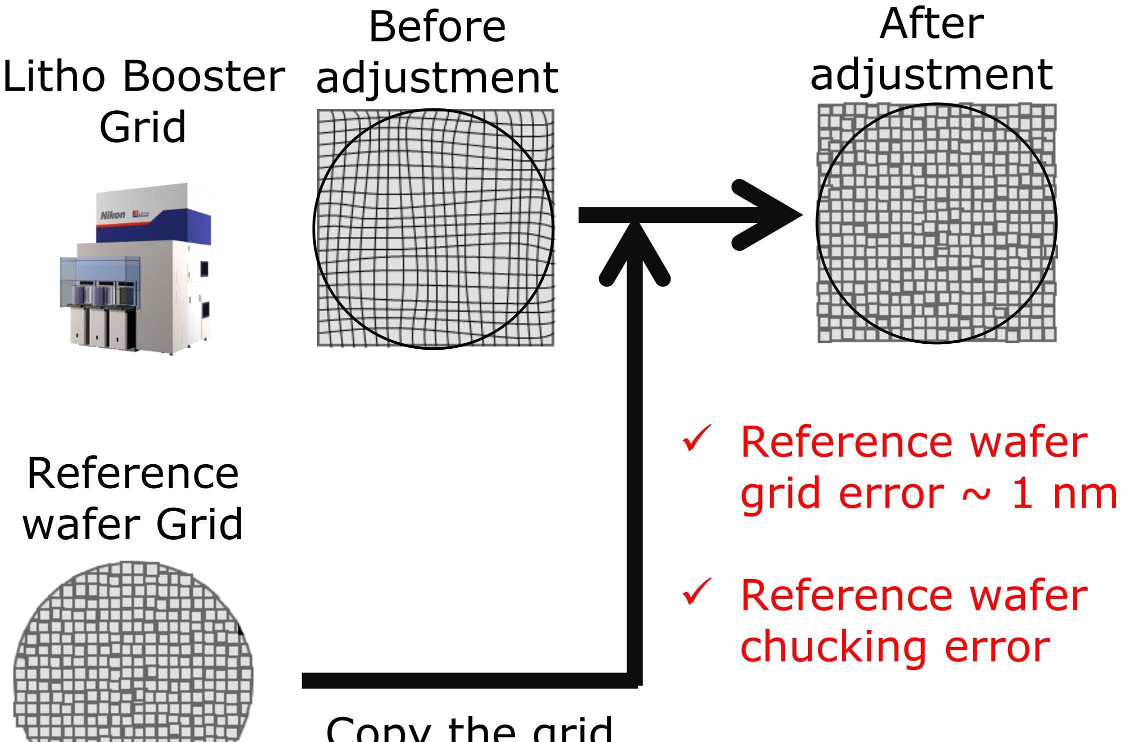
High speed and high-density sampling

Subject : How to construct highly accurate coordinate system on Litho Booster

Correction of Litho Booster's grid

Reference wafer method

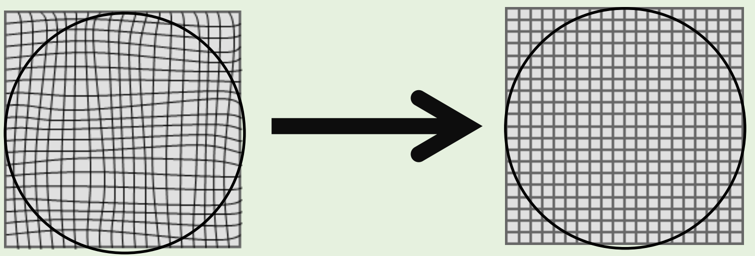
- ✓ Copy the reference wafer grid to Litho Booster's coordinate grid



- ✓ Reference wafer grid error ~ 1 nm
- ✓ Reference wafer chucking error

Absolute grid method

- ✓ Direct grid adjustment using Litho Booster's stage encoder

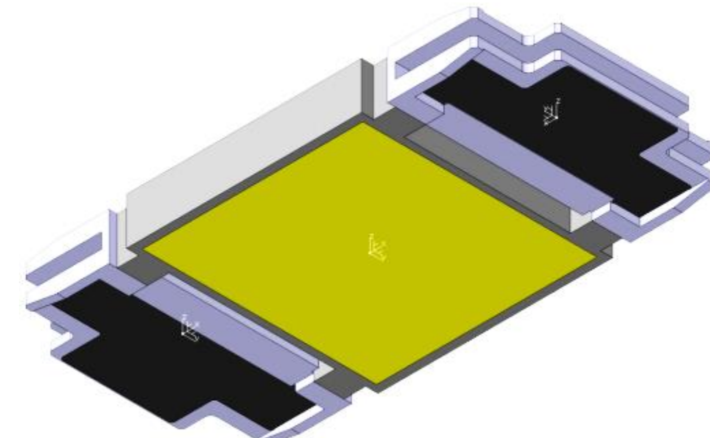


- ✓ Free from reference wafer induced-errors

LB wafer stage with backside metrology system

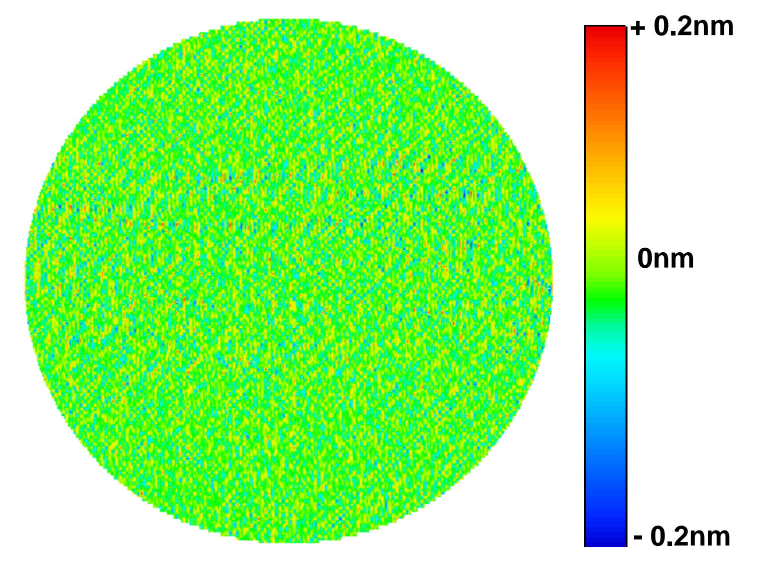
Backside metrology system

position sensing,
just below ALG measurement point



Metrology plate for backside encoder

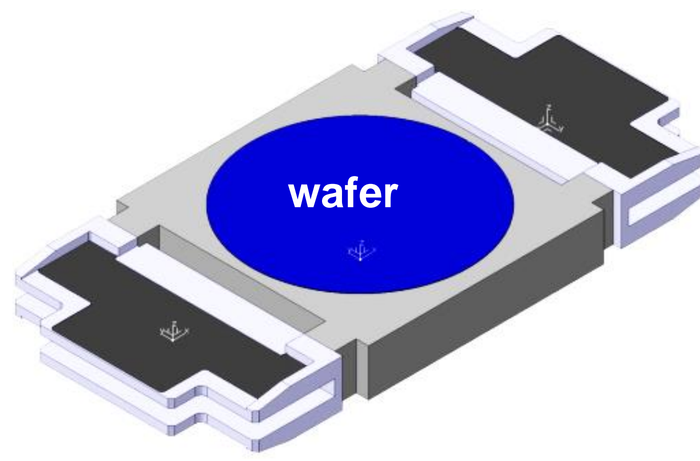
- ✓ Large size grating plate
- ✓ Smooth grating and flat surface



High order position error (XY)

0.13 nm (3 sigma)

Front side



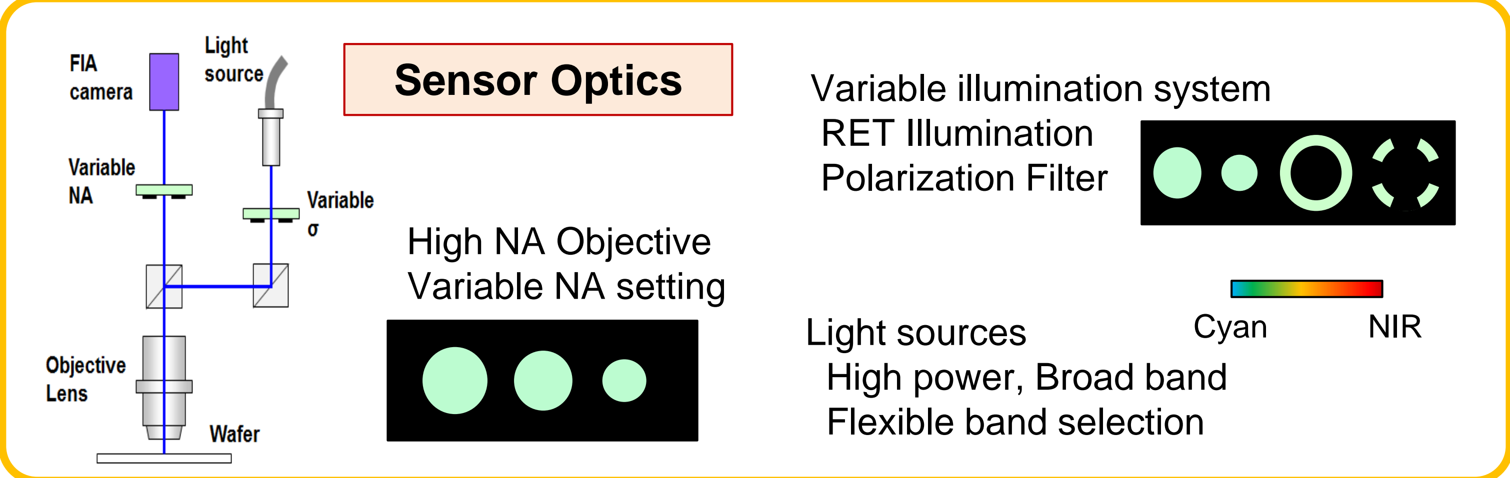
Monolithic structure stage

- ✓ Rigid body
- ✓ High speed

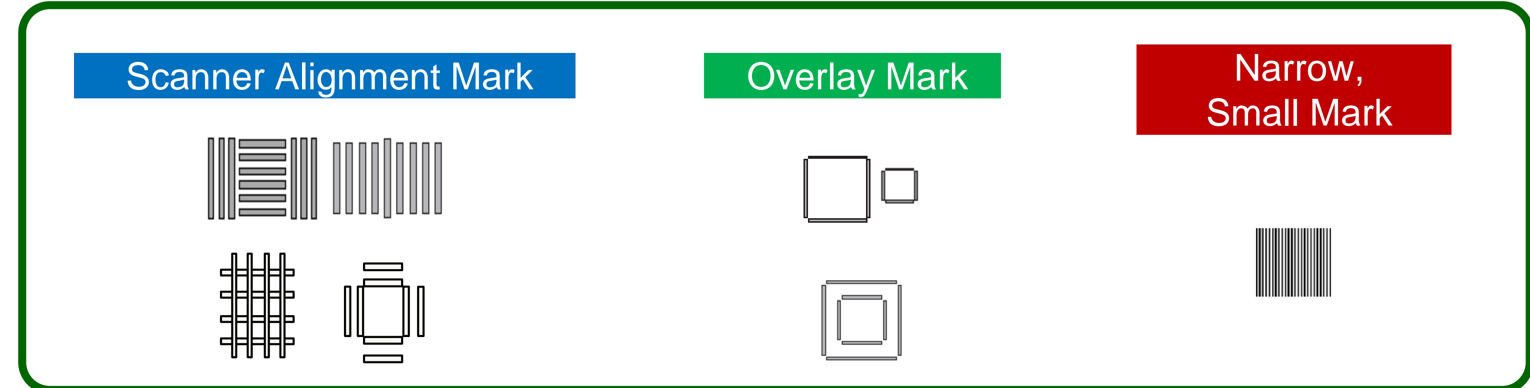
High Accuracy Imaging Sensor: iFIA

锐布 Litho Booster

- Newly developed high accuracy imaging optics

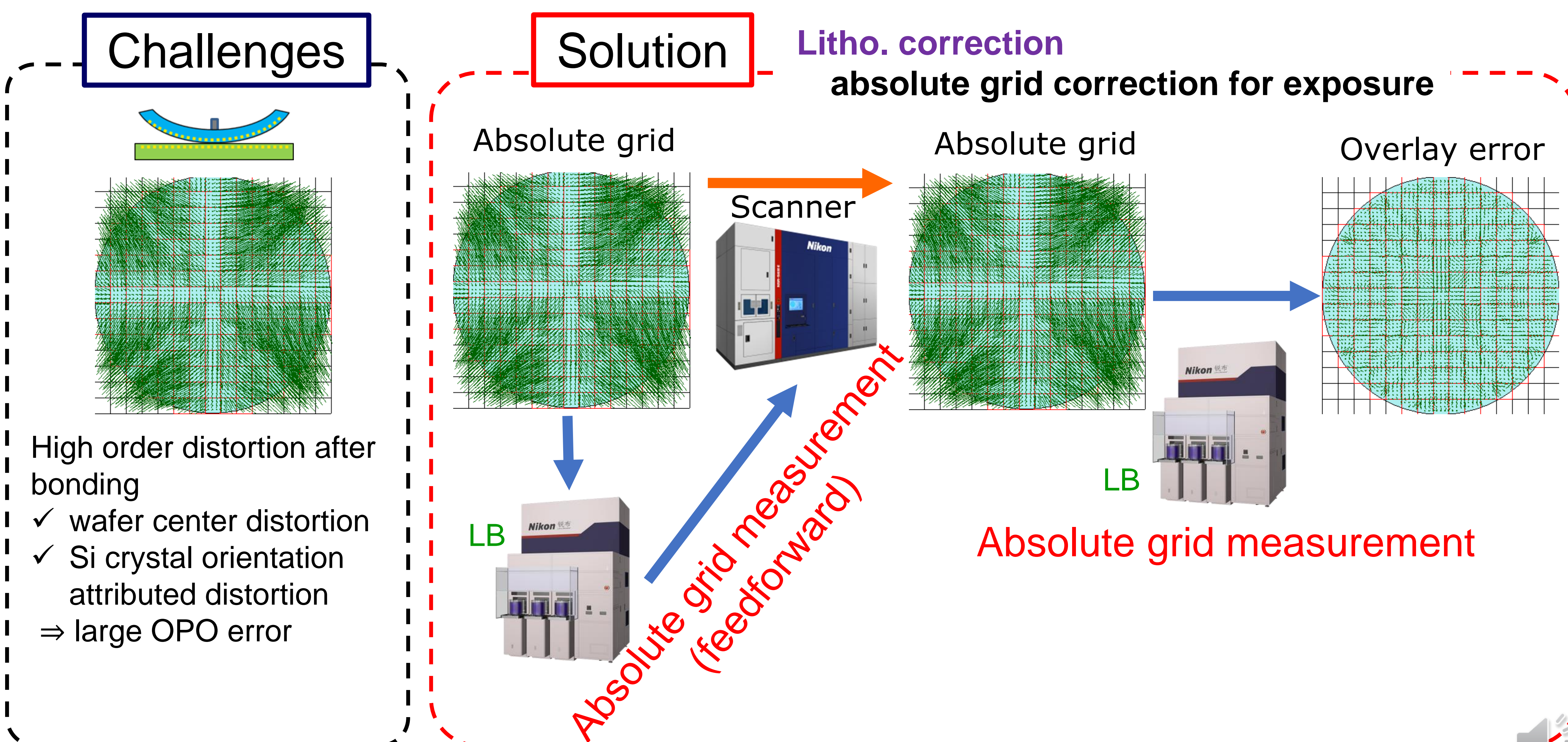


- Detection capability for wide ranging mark



Litho Booster can measure various marks with high accuracy under various process conditions

Solution for bonding wafer overlay



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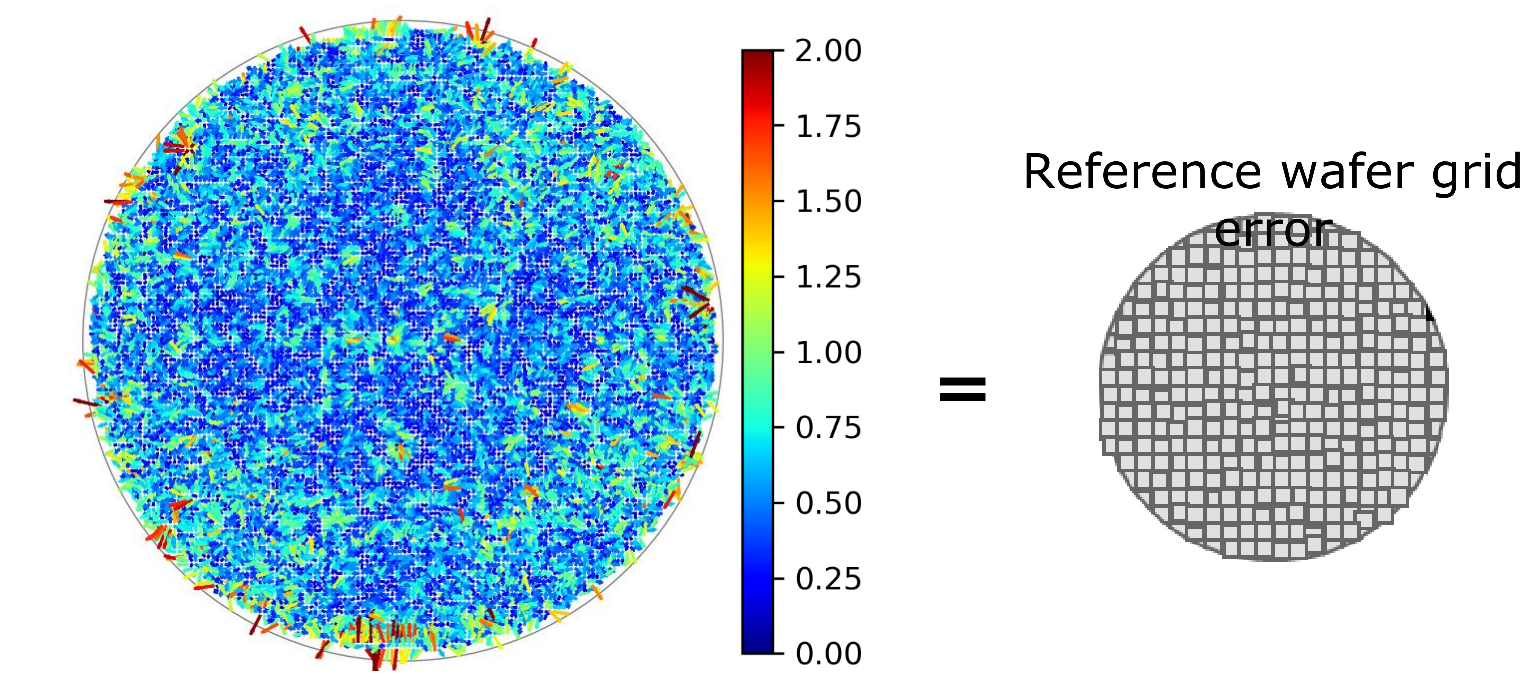
Performance data

- Alignment accuracy improvement using absolute grid
- Absolute coordinate stability
- Absolute grid measurement for bonding wafer

Alignment accuracy improvement using absolute grid

Evaluation method

1. Adjust Litho Booster grid by absolute grid
2. Measured reference wafer grid error

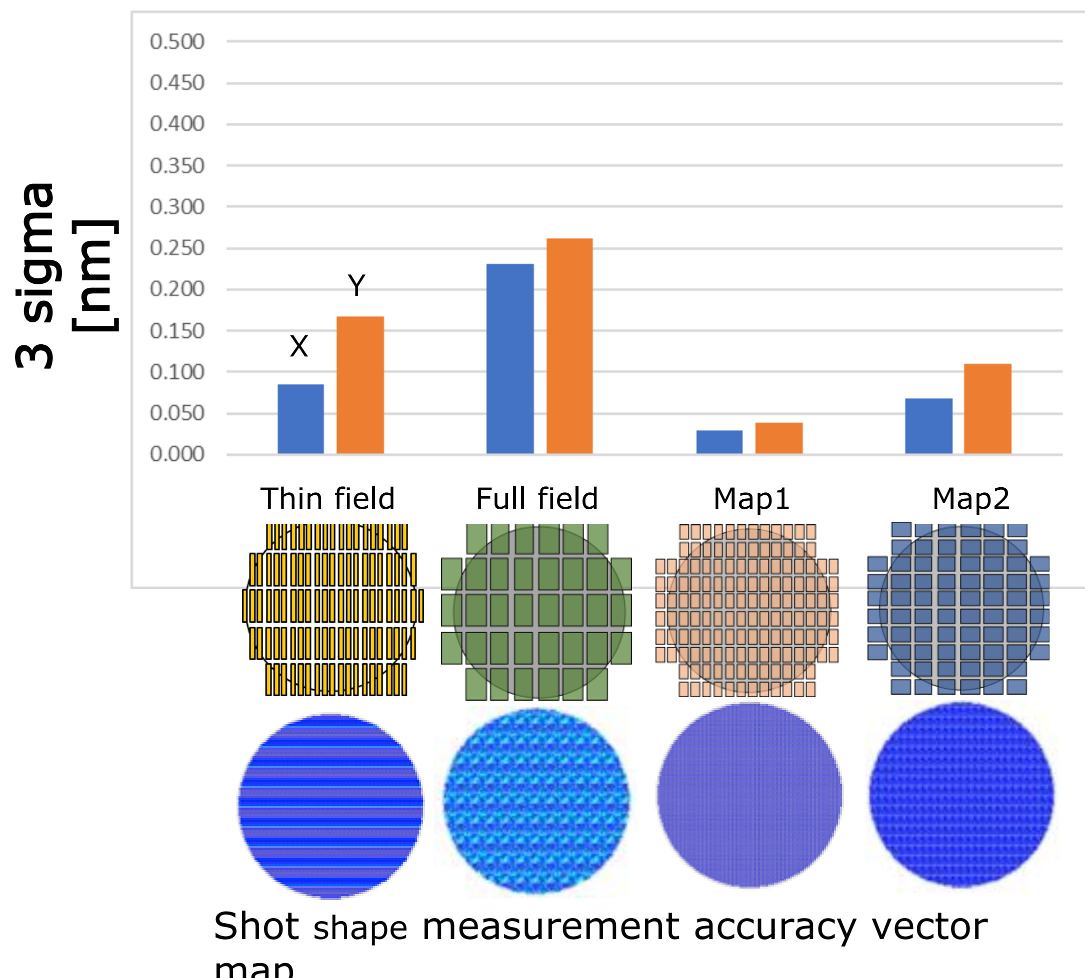


X3sigma: 1.3 nm, Y3sigma: 1.2 nm

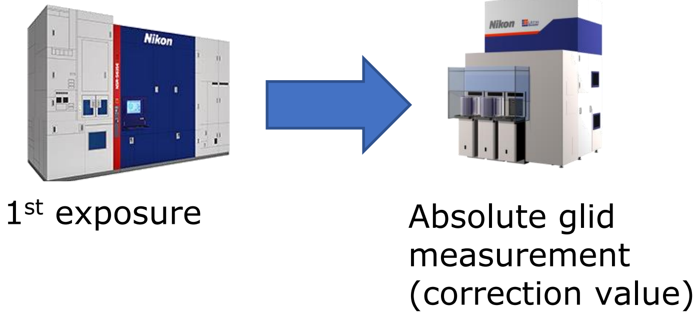
Alignment accuracy can be improved by 1.3 nm

Shot shape measurement accuracy improvement

Average shot shape



Shot shape measurement accuracy vector map

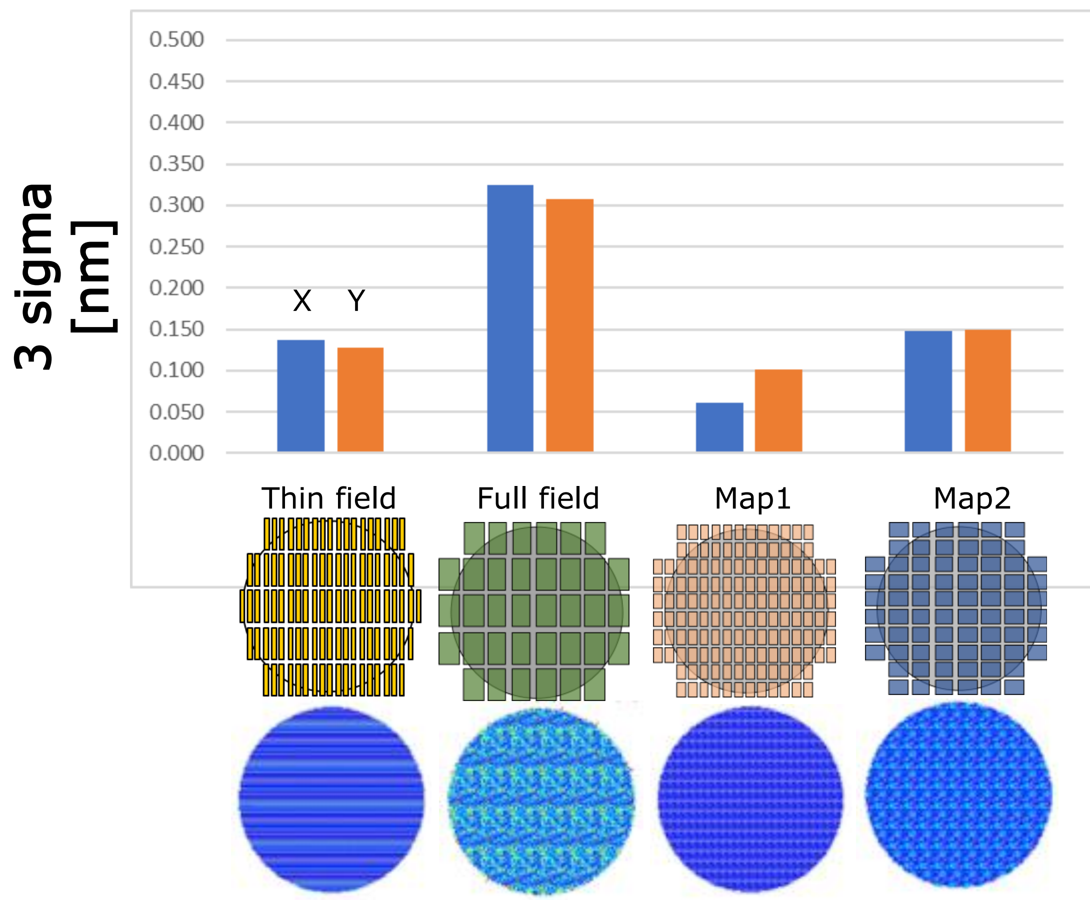


- Verify shot shape measurement accuracy difference between reference wafer grid and absolute grid method
- Calculate 3 sigma of shot shape difference for each exposure map
  : (reference wafer grid) – (absolute grid)

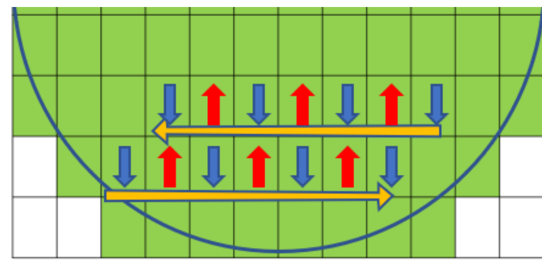
Average shot shape measurement accuracy improved 0.25nm

Shot shape measurement accuracy improvement

Scan / winding dependance shot shape



Shot shape measurement accuracy vector map



Scan / winding direction

- Exposure tools have shot shape difference due to scan / winding direction dependence
- Evaluate shot shape difference between reference grid and ideal grid to estimate overlay improvement for absolute measurement method

Scan / winding dependance shot shape measurement accuracy improved 0.30 nm

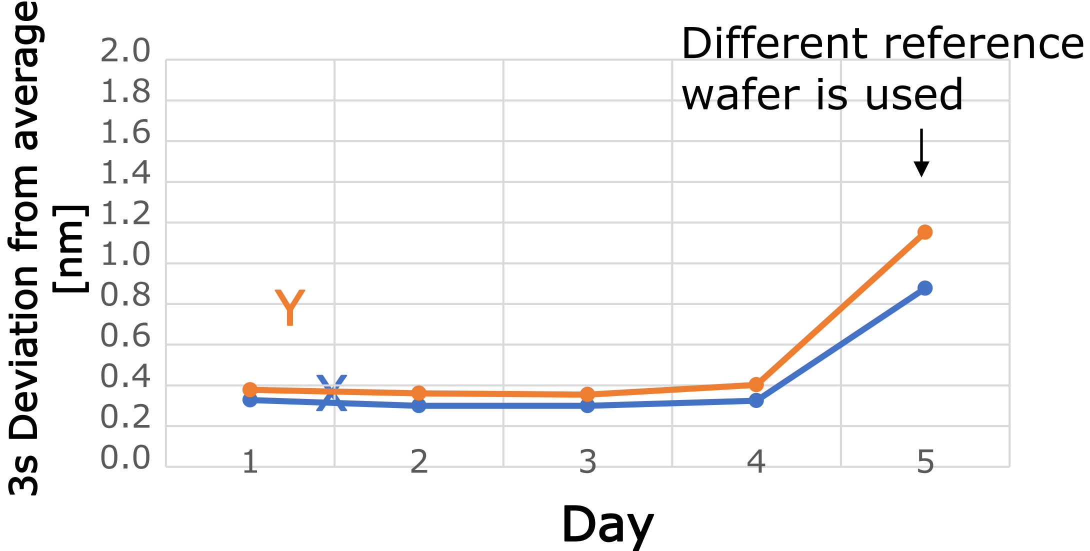
Overlay correction value accuracy is improved by absolute measurement method

Absolute coordinate stability

Reference wafer method

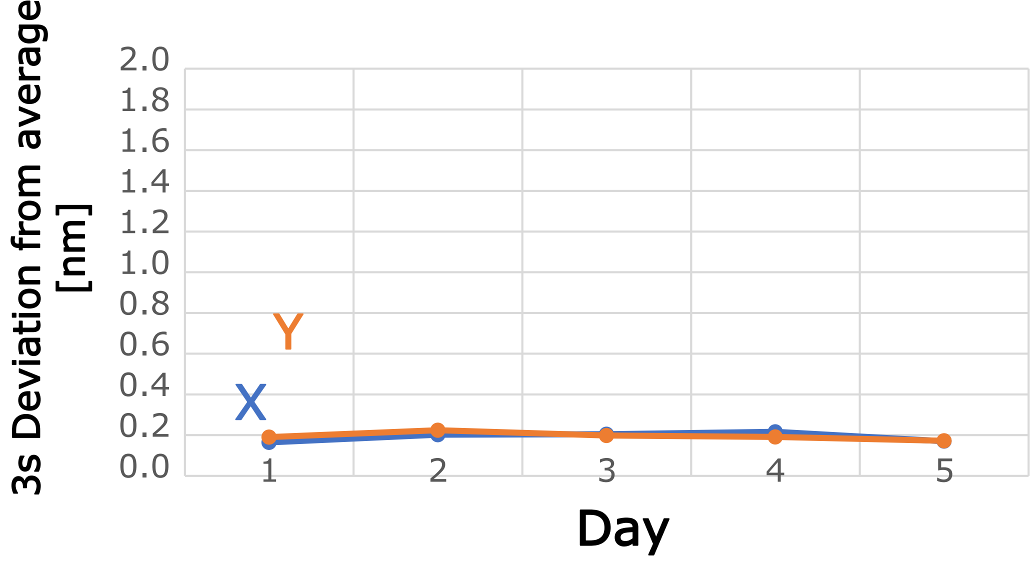
chucking error

reference wafer grid error



Absolute grid method

Free from reference wafer induced-errors



Absolute grid adjustment stability ≦ 0.2 nm

Absolute grid measurement for bonding wafer

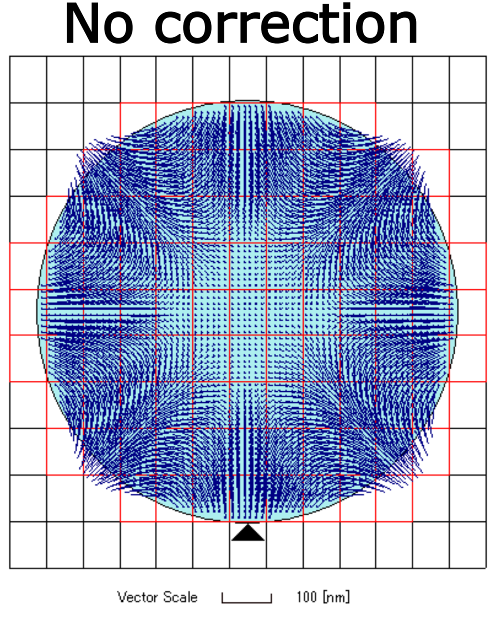
Actual data
(measured by LB)

120
100
80
60
40
20
0
3 sigma (nm)
Wafer #1
Wafer #2
Wafer #3
Average
X Y

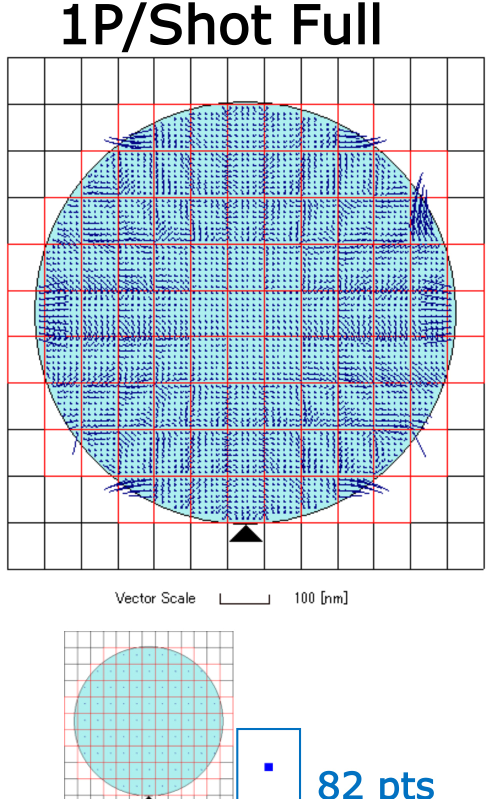
	Actual data	
	X	Y
3 sigma	107 nm	101 nm

Absolute grid of bonding wafer is around 100nm

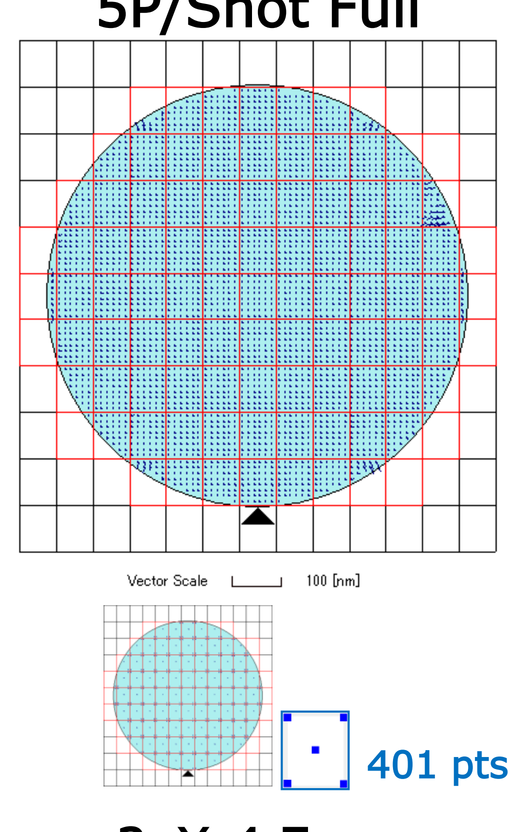
Overlay Simulation for bonding wafer



3σX:76.4nm
3σY:76.9nm



3σX:27.7nm
3σY:22.4nm



3σX:4.7nm
3σY:4.7nm

Correction			
Correction	Grid	Map correction	Map correction
	Shot	-	Each shot linear

Quoted from IWAPS 2021 : Masuyuki (Nikon)

Productivity Simulation for bonding wafer

Overlay residual 3σ vs. Measurement point

Residual 3σ [nm]: 0, 5, 10, 15, 20, 25, 30

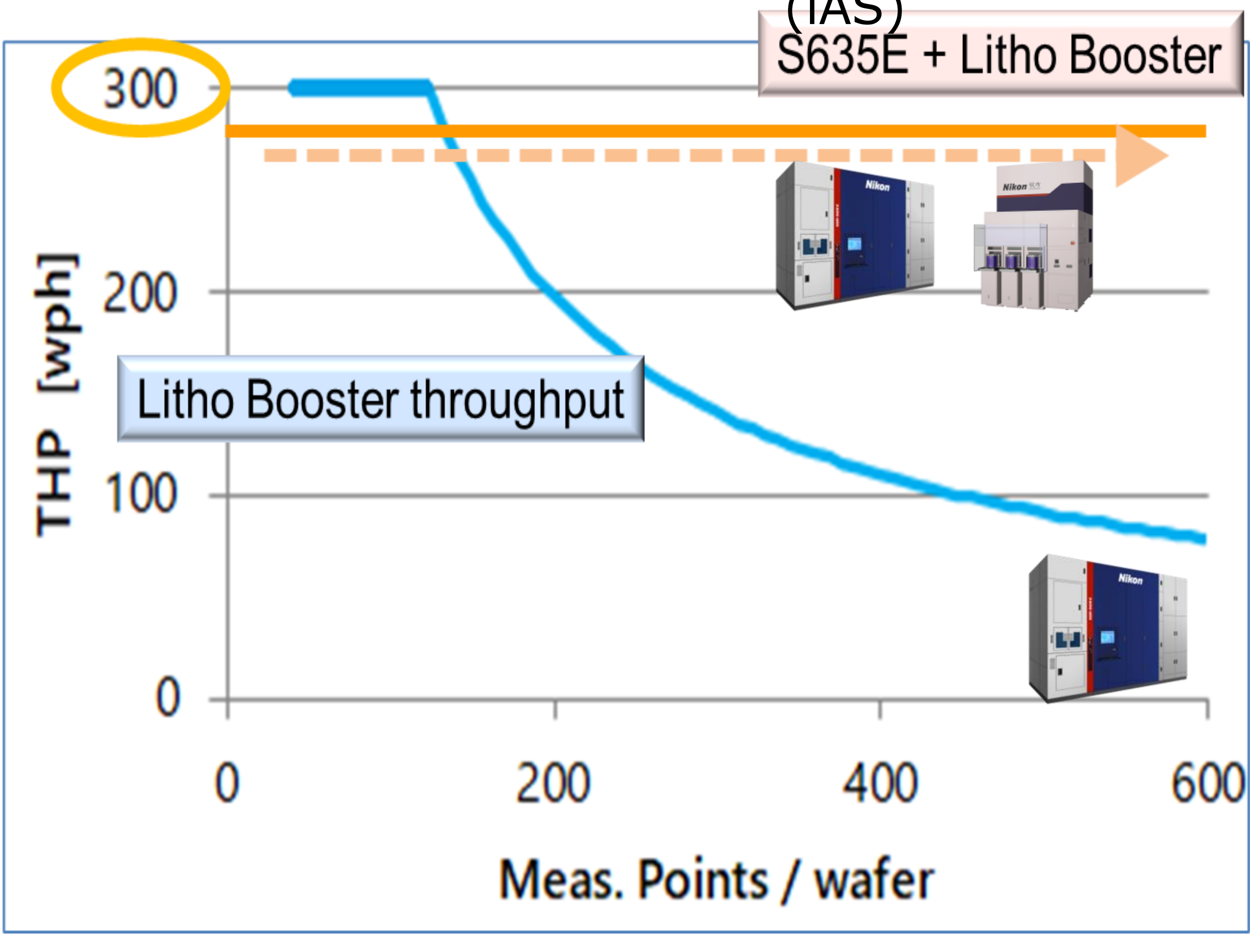
Measurement point: 0, 500, 1000, 1500, 3000, 3500, 4000

82 pts

401pts

715 pts

3815 pts



iAS: inline Alignment Station

Quoted from IWAPS 2021 : Masuyuki (Nikon)

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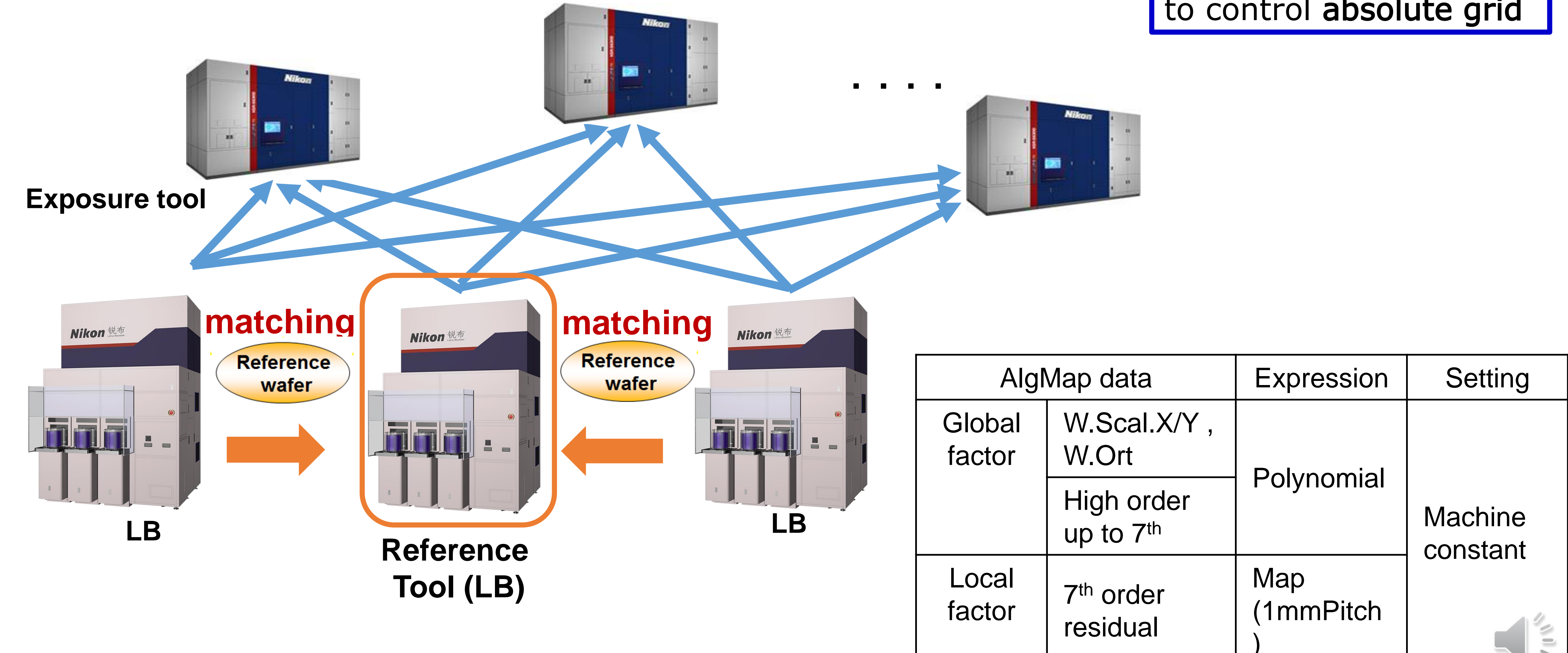
Grid control by Zeroing system

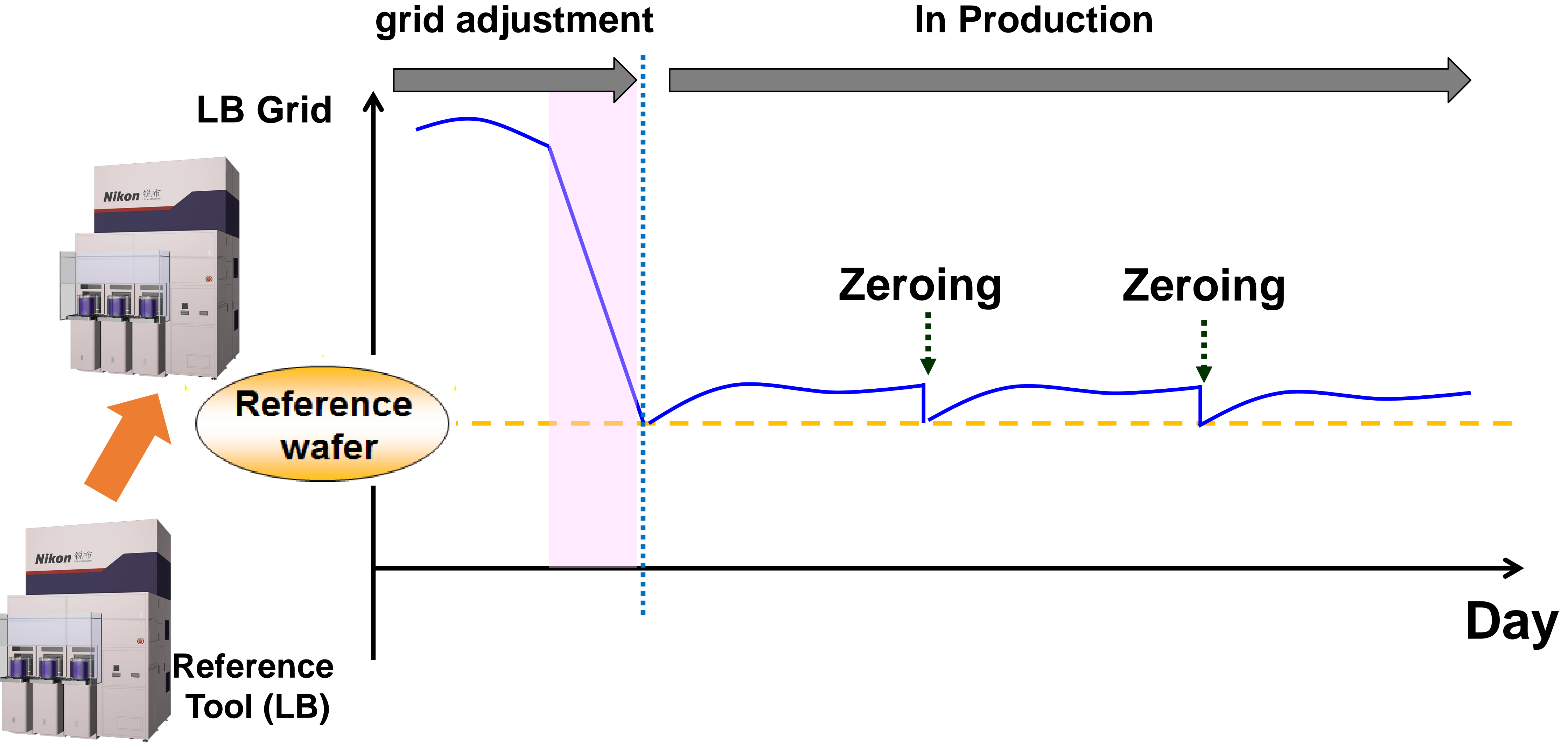
■LB match to reference LB with reference wafer

Reference wafers used to control **absolute grid**



AlgMap data		Expression	Setting
Global factor	W.Scal.X/Y , W.Ort	Polynomial	Machine constant
	High order up to 7th		
Local factor	7th order residual	Map (1mmPitch)	

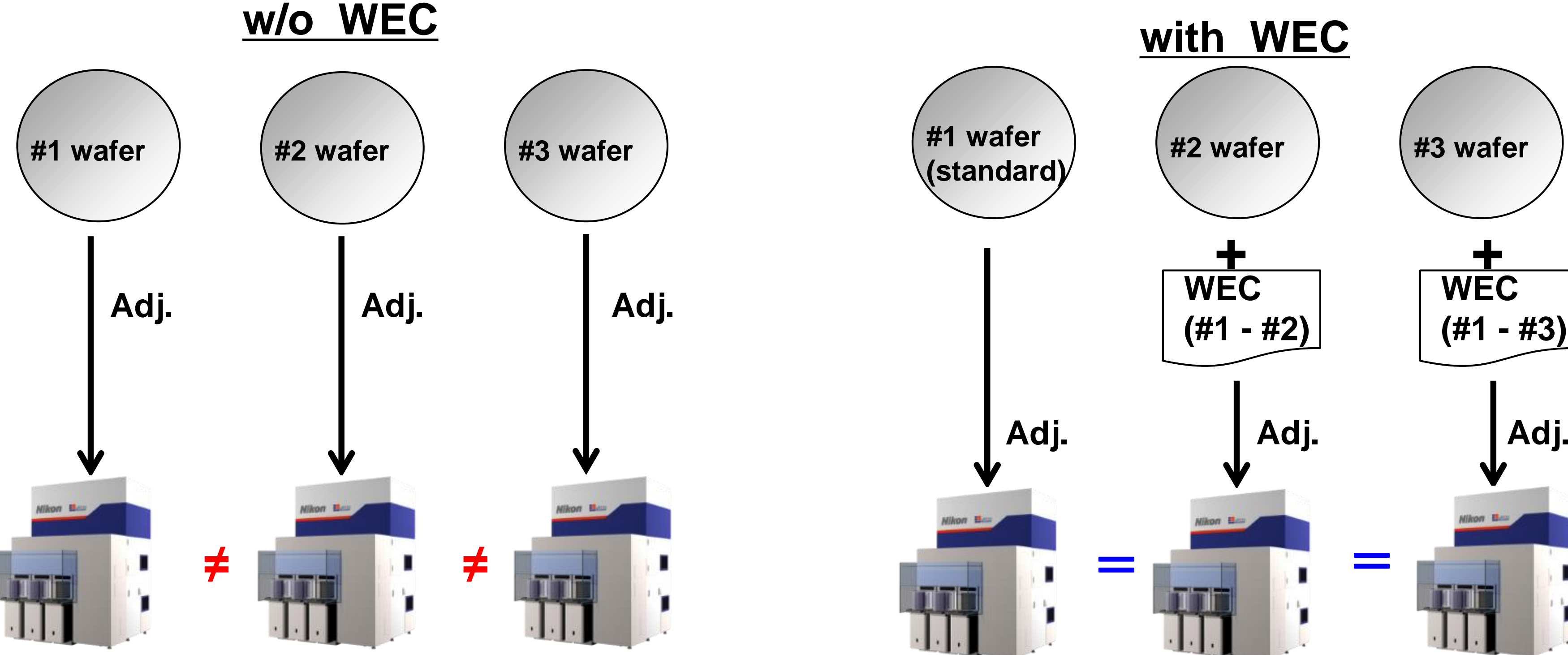
Periodical gird correction



Zeroing keeps the shape after grid adjustment with reference wafer.

Wafer Error Correction (WEC)

- Purpose
  - Cancel wafer fabrication error
    - Grid management with multiple reference wafers.
    - Keeping previous grid in case of changing wafer to new one.
  - Difference from standard reference wafer



Multiple reference wafers can be used as the reference wafer with WEC

Zeroing Correction simulation

w/o Zeroing Corr.

Grid 3sigma

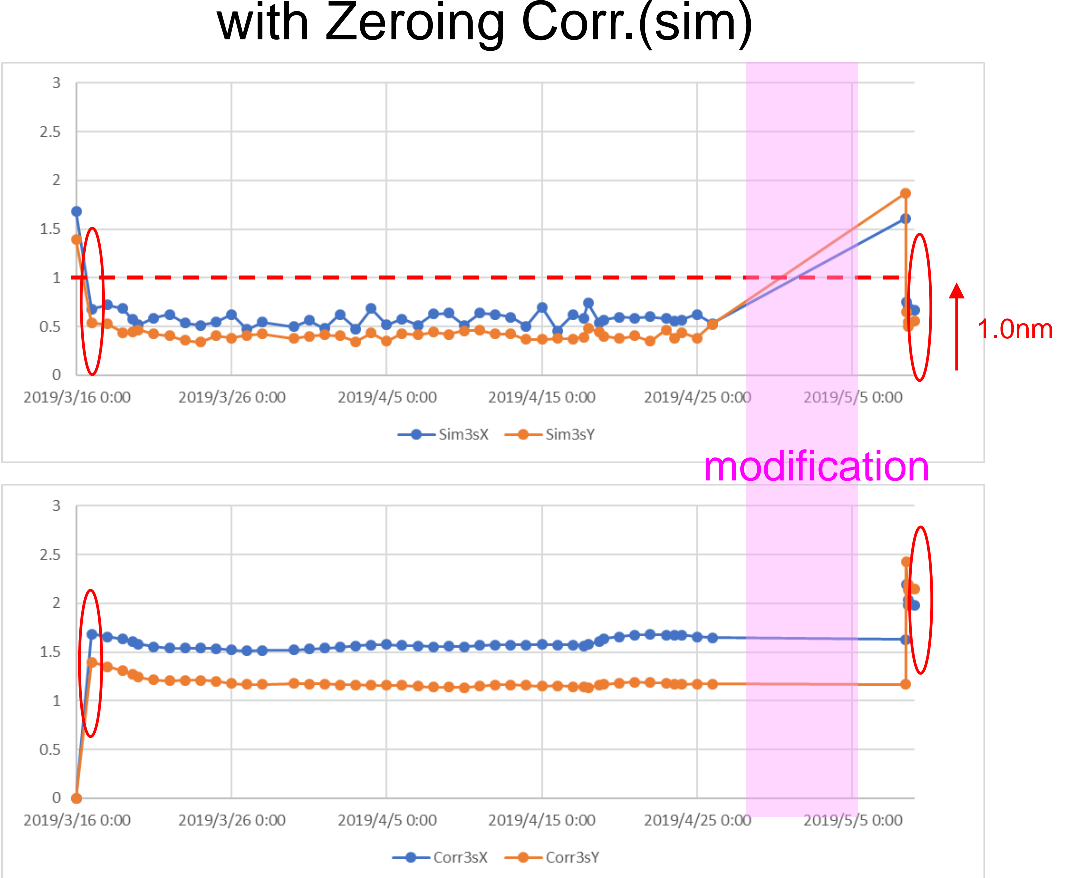
3sX 3sY

1.0nm

modification

Zeroing Corr. value

Corr3sX Corr3sY



Zeroing can keep grid stable

Zeroing can back LB grid to original correctly after modification

Conclusions

- Ideal scanner's absolute grid correction using a standalone alignment metrology system has been proposed.
- Accuracy and stability of absolute grid was demonstrated.
  - Accuracy of alignment improvement: 3sigma 1.3 nm
  - Absolute grid stability: ≦ 0.20 nm.
- Absolute grid for LB can be controlled by Zeroing.

Nikon