



Integrated Solution of Nikon Exposure, Metrology and Inspection

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Sector Manager

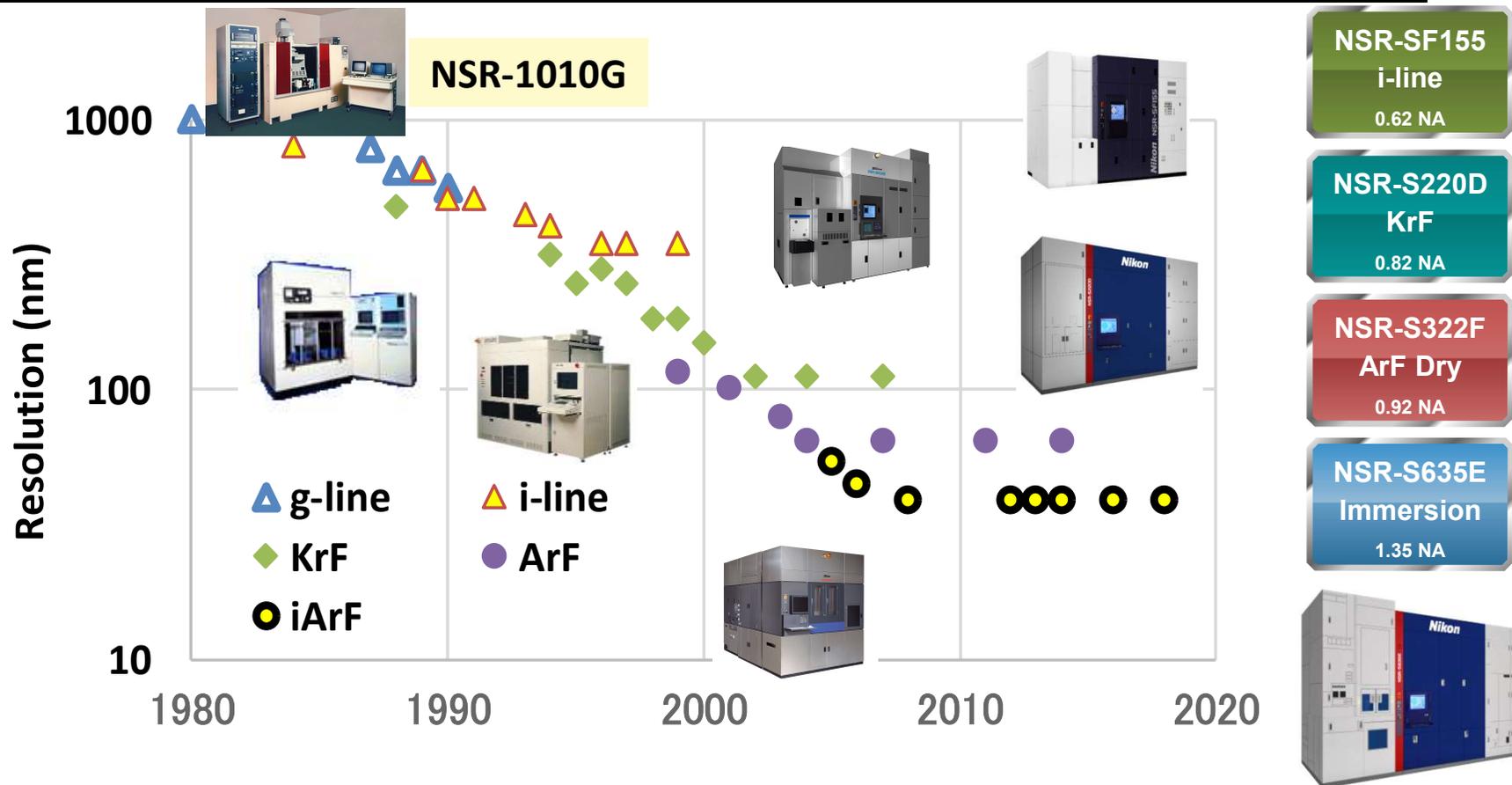
Semiconductor Lithography Business Unit

NIKON CORPORATION

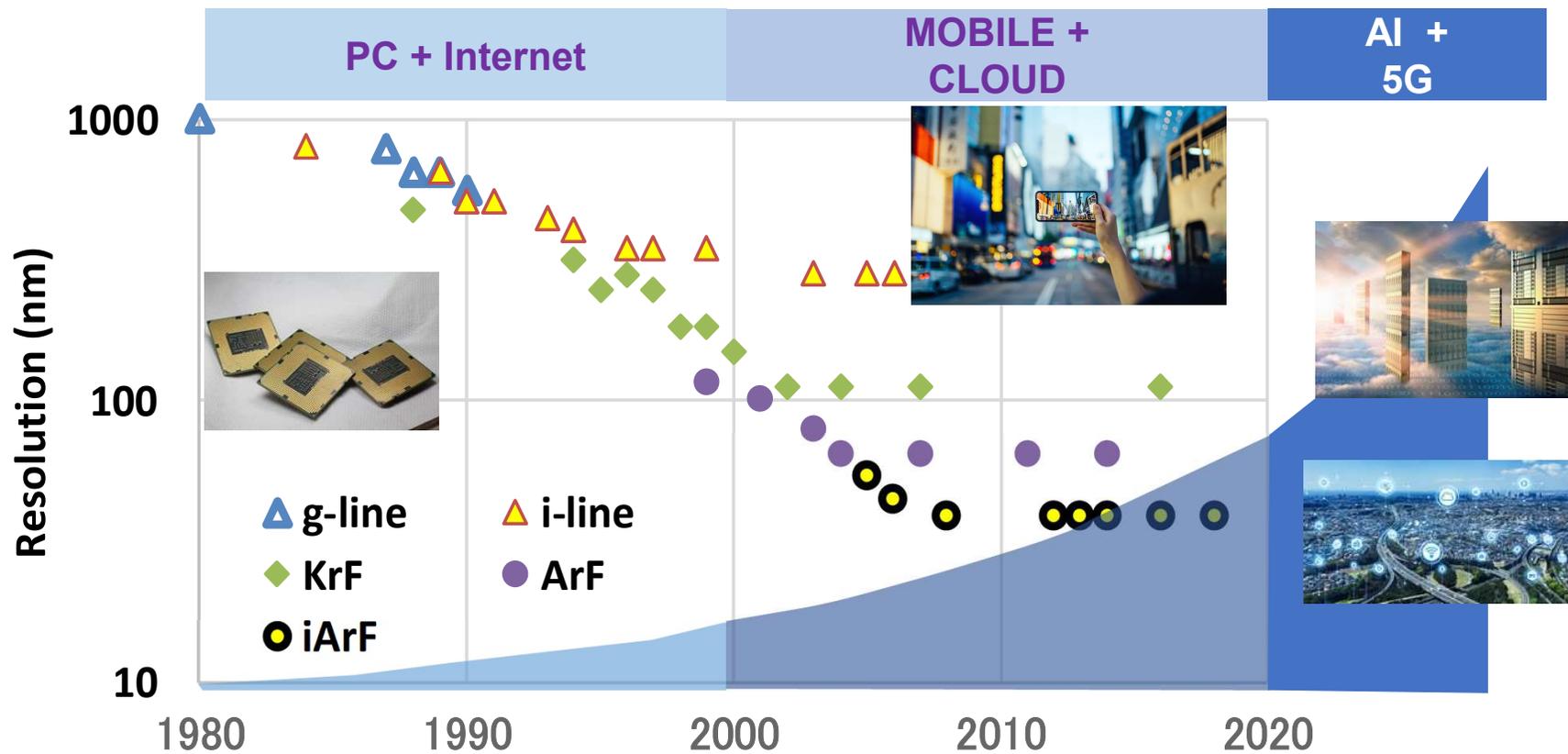




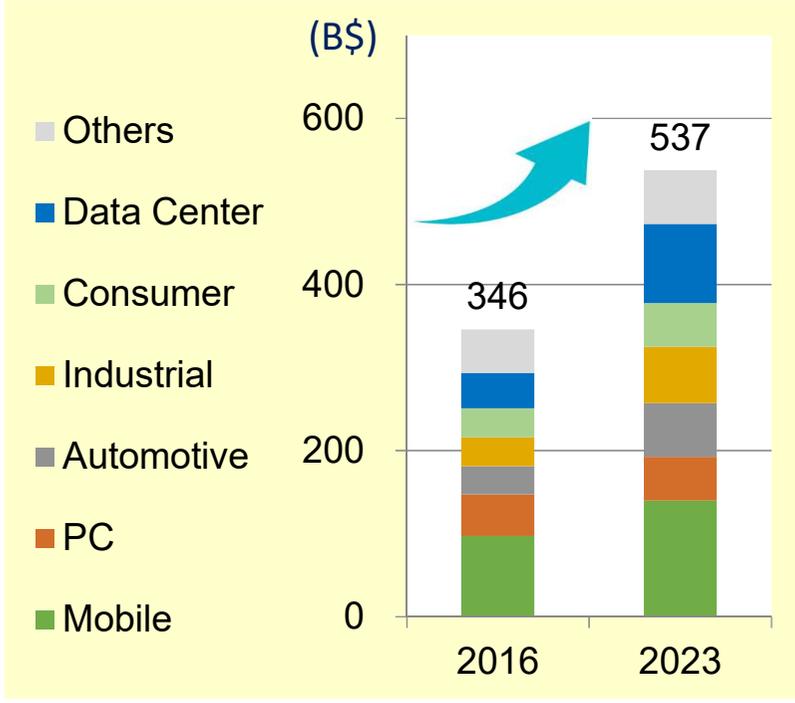
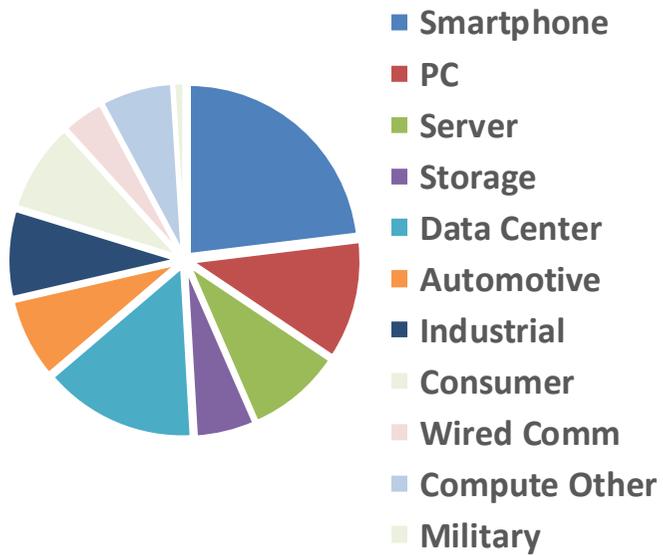
NSR contribution for LSI innovation



NSR contribution for LSI innovation

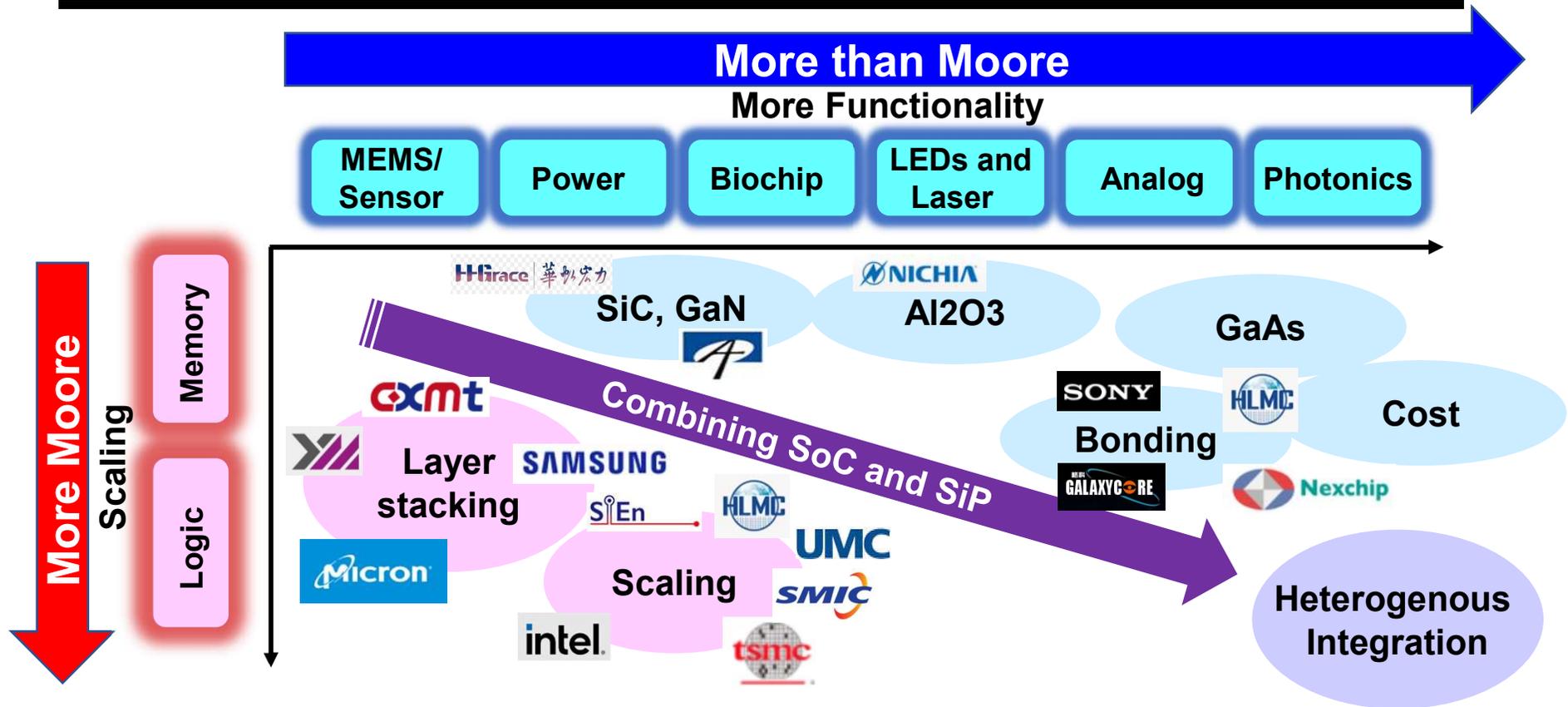


Market trend

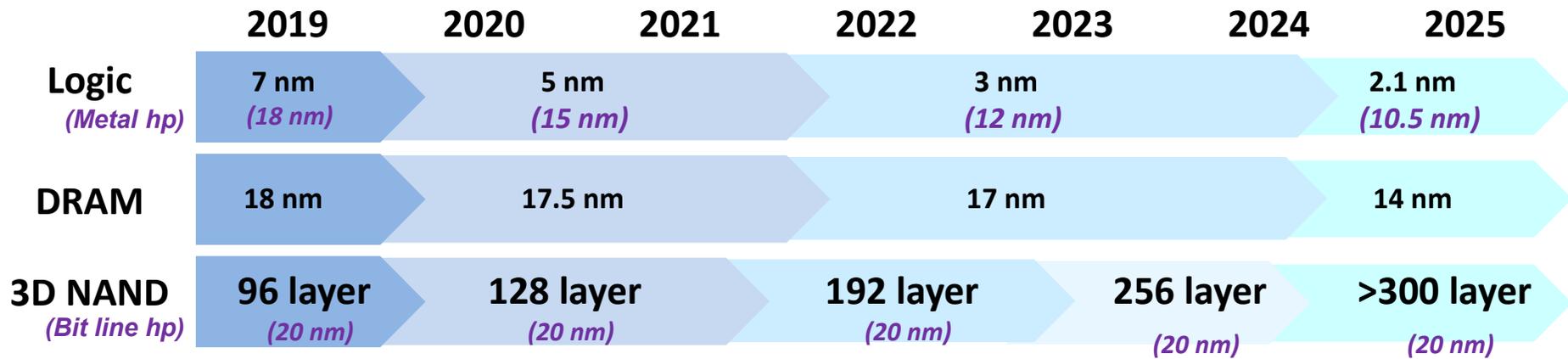


Source: Nikon estimation based on Gartner data

Semiconductor products



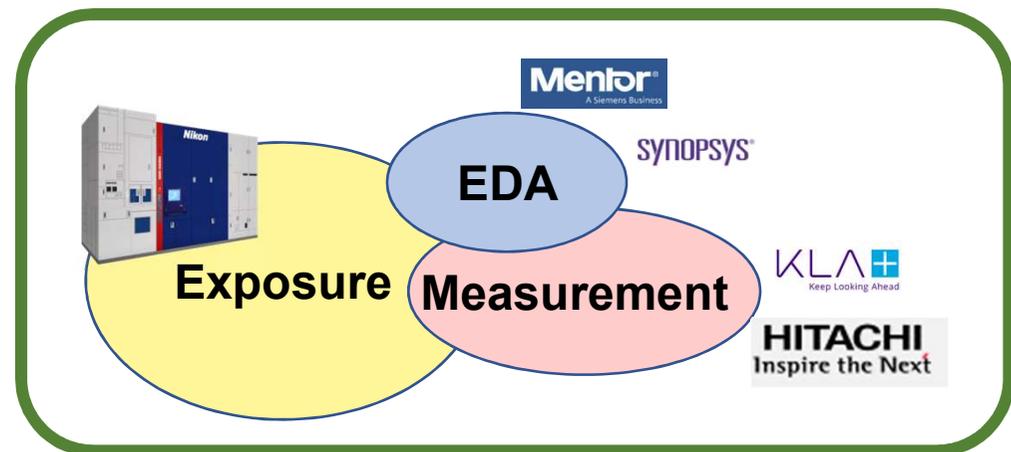
More Moore



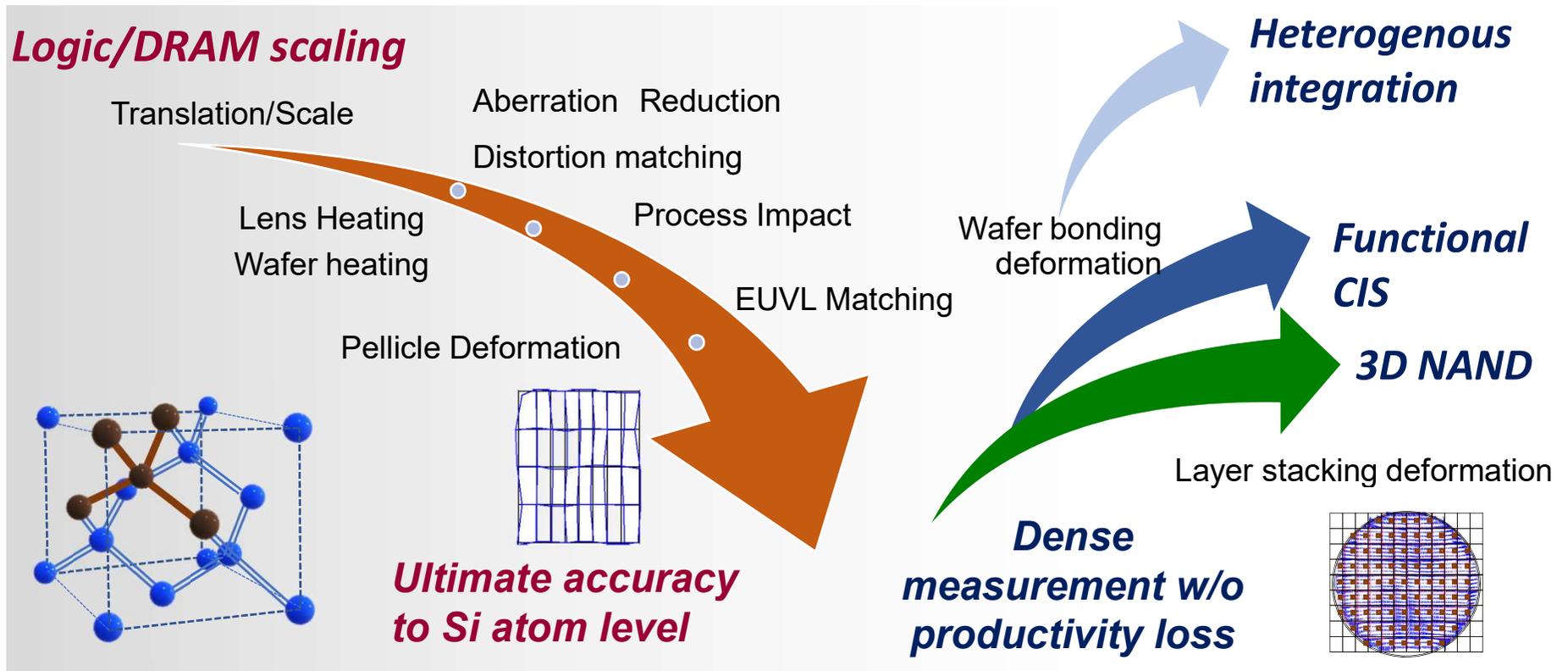
Key technologies

- EUVL implementation at cutting edge
- EPE improvement on all devices
(Overlay, OPC, measurment)

Source: IRDS roadmap 2020
Nikon customer research



On-Product Overlay (OPO) Key Factors



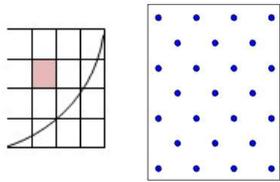
Dense sampling for On-Product Overlay(OPO)



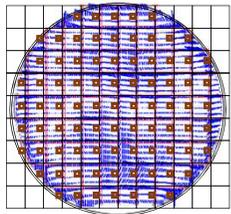
Measure under layer distortion w/ high accuracy



Reflect to overlay exposure correctly



Intra-Field dense sampling distorted intra-field layer

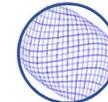


All shot grid sampling for large distorted layer



✓ Field by Field higher order Intra-field matching

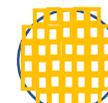
✓ Multi grid matching model



Polynomial Model



Edge Local Model



Die by Die Model

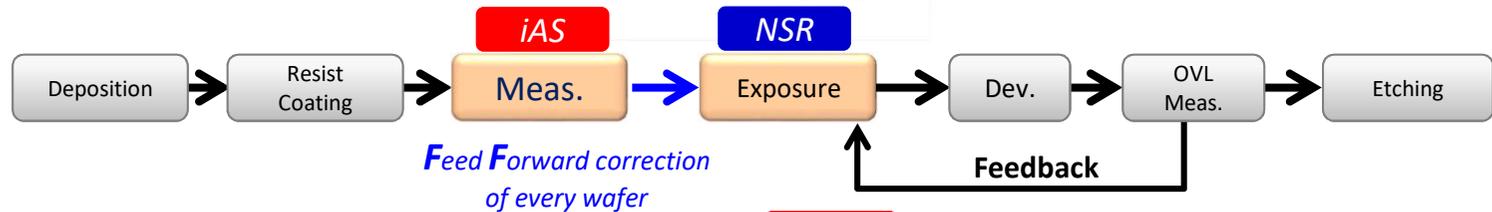
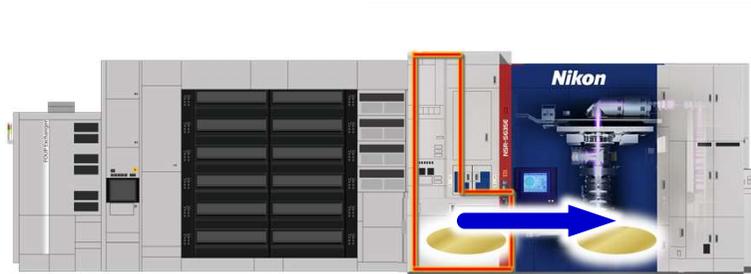
Dense sampling and FF is breakthrough for under layer matching

Latest ArFi with iAS (inline Alignment Station)



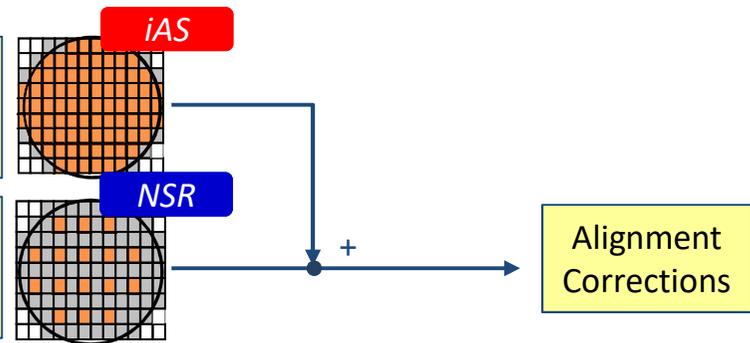
NSR-S635E
ArFi

1.35 NA
MMO <2.1 nm
>275 wph



Measure and FF
- Dense sampling
- Higher order grid correction

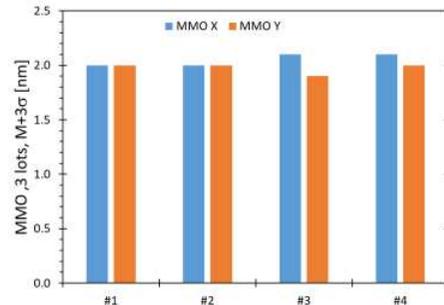
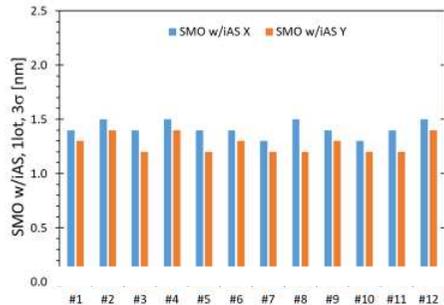
Alignment on the NSR
- Sparse sampling
- Linear grid correction



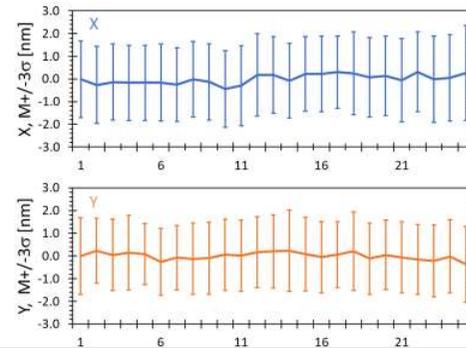
S635E performance



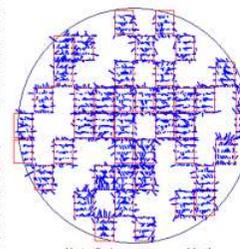
SMO and MMO performance



MMO performance

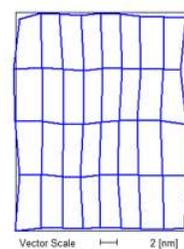


Grid + Distortion Matching



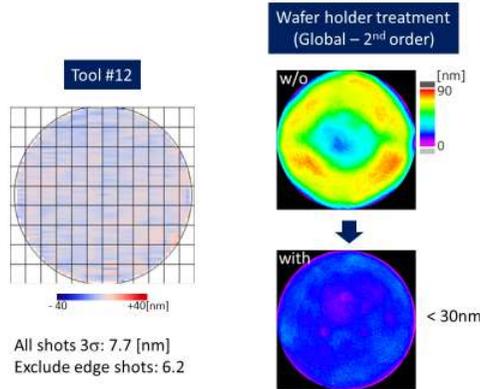
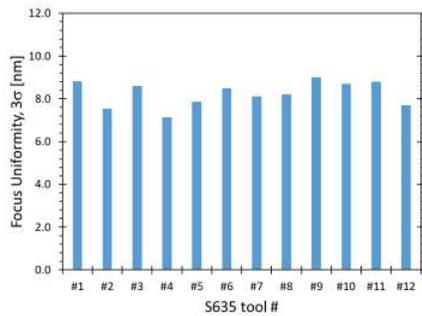
Vector Scale 1 [nm]
3σ X: 1.11
3σ Y: 1.01 [nm]

Distortion Matching

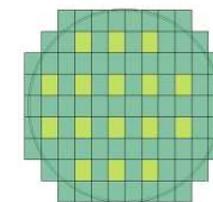
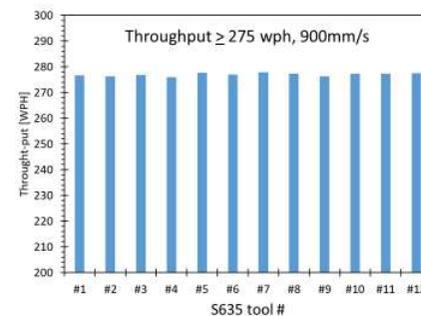


Vector Scale 2 [nm]
3σ X: 0.74
3σ Y: 0.48 [nm]

Focus uniformity control



Throughput performances



Shot size: 26 x 33 mm
Shot #: 96 shots

S635E performed good performance for OVL / Focus / WPD

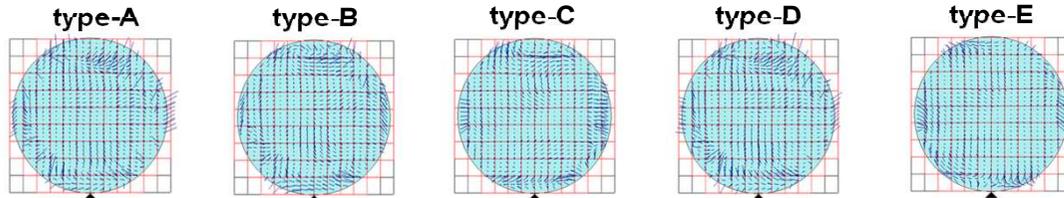
OPO with proper dense alignment



1st Exposure Given grid

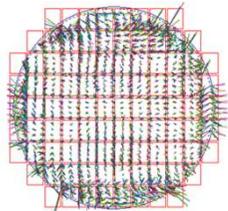
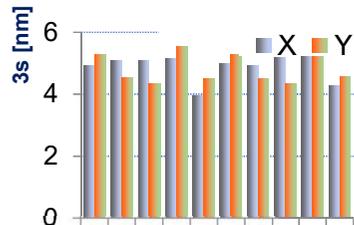
- 7th order error
- 5 error types
- 2 wafers each

Vector scale 20 nm



2nd Exposure Overlay Result

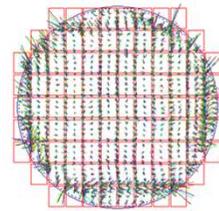
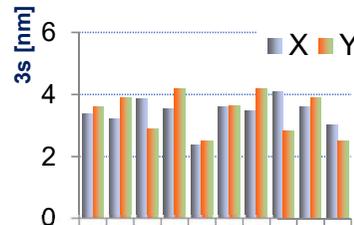
- ✓ 16 point EGA w/o iAS
- ✓ Linear correction



**X: 4.59
Y: 4.50**

3s [nm]

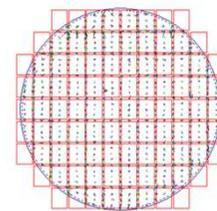
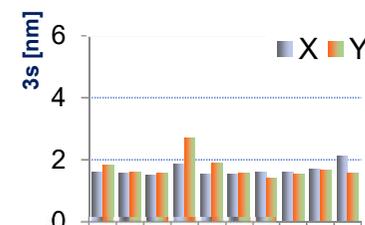
- ✓ 40 point EGA w/ iAS
- ✓ 5th order correction



**X: 3.20
Y: 3.36**

3s [nm]

- ✓ 84 point EGA w/ iAS
- ✓ 7th order correction



**X: 1.81
Y: 1.83**

3s [nm]

S635E improves OPO with dense sampling without THP drops

Solution for overlay upgrade



At new fab is OK with the latest ArFi
How about existing fab for enhancement ?
Replacing to the latest scanner is too expensive

Litho Booster (LB)

- Standalone alignment station as same as scanner
- Feed forward by absolute measurement
 - ◆ Improvement for distorted wafer overlay
 - ◆ Scanner finger print correction
 - ◆ Solution for the unknown in overlay measurement
- Improvement for existing scanner system



Fab enhancement with overlay improvement



- 65 nm logic → 55 nm logic
 - ✓ M1 pitch: 180 nm → 160 nm
 - ✓ Scanner : ArF dry → ArFi
 - but ArF dry has sufficient resolution
 - ArF dry + LB for dense meas.



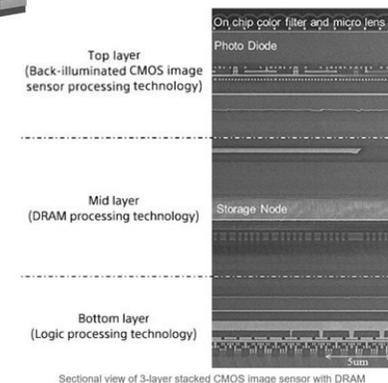
NSR-S322F

0.92 NA

MMO < 5.0 nm

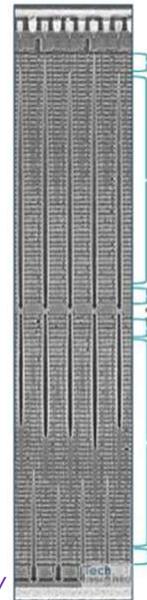
> 230 wph

- Back-illuminated CIS / 3-Layer stacked CIS
 - ✓ In-plane distortion by wafer bonding (Image sensor, logic, memory)
 - but same design rule (Needs of current tools usage)
 - Current Scanner + LB for dense measure



Source: *1/2.3in 20Mpixel 3-Layer Stacked CMOS Image Sensor with DRAM, ISSCC (2017)*

Source: <https://www.techinsights.com/>



Integrated Solution of Metrology and Exposure

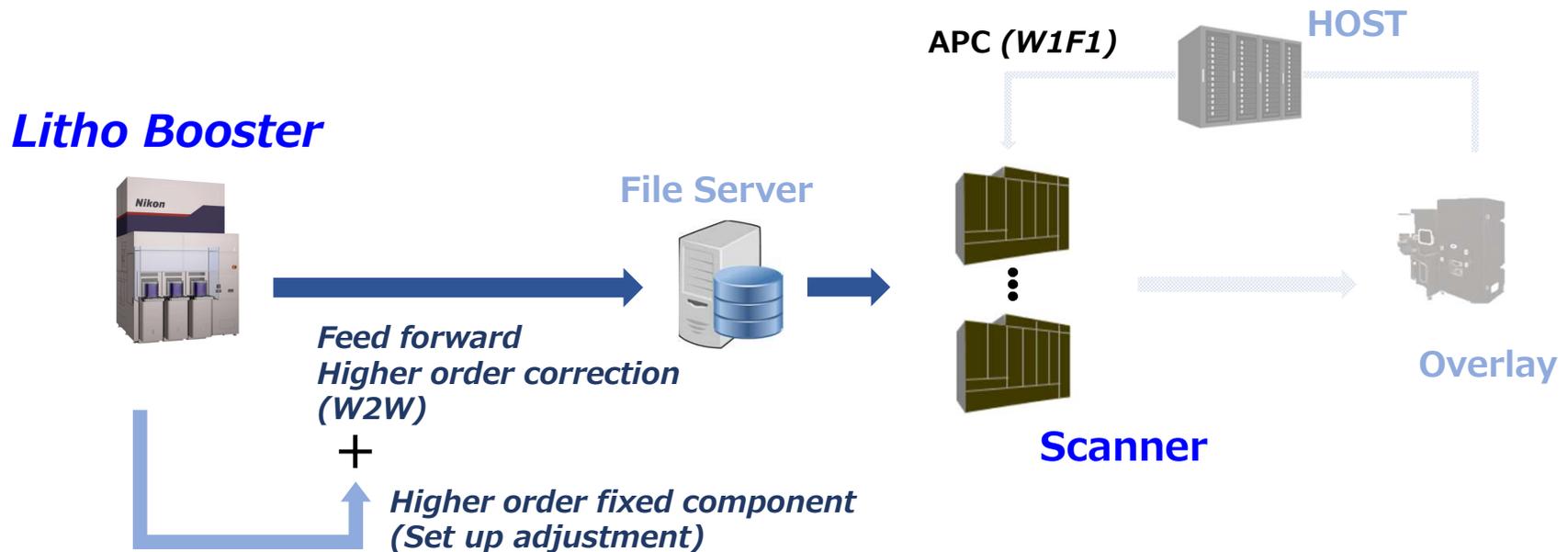


Can be coupled with any scanner



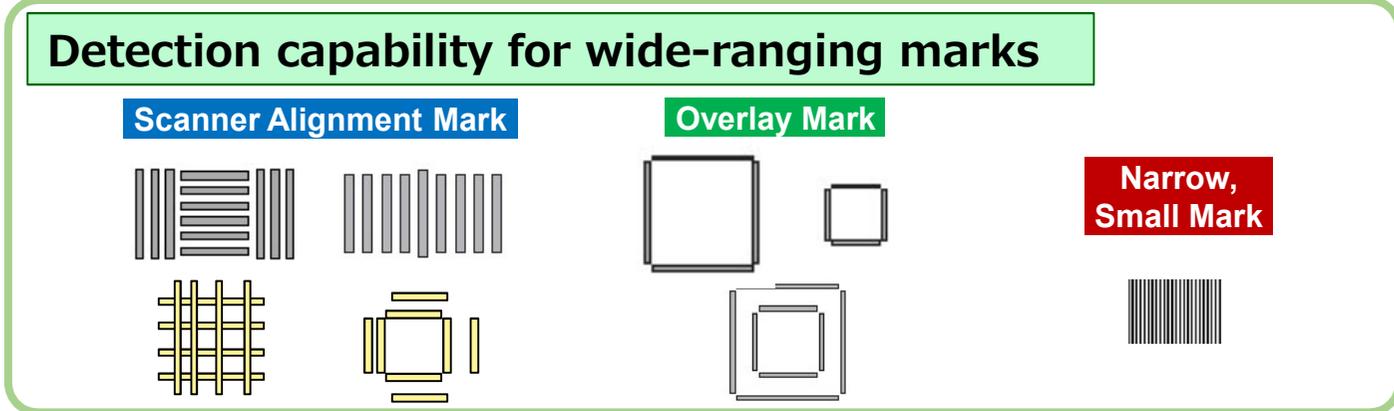
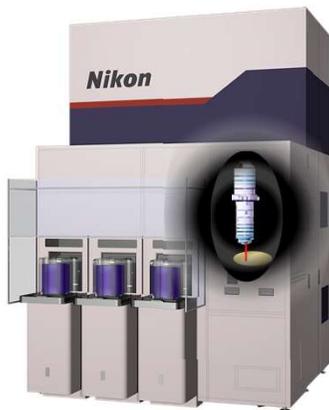
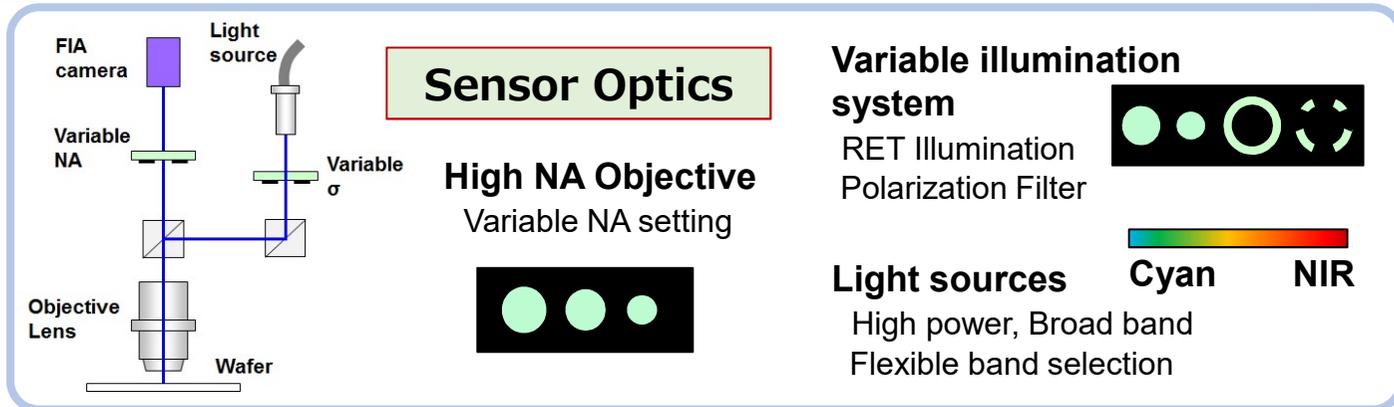
LB measurement result can be fed forward to any scanner

Use case of standalone alignment station



- APC liner correction
- Litho Booser higher order correction
- *Feed forward correction doesn't impact to APC*

High accuracy imaging sensor: iFIA



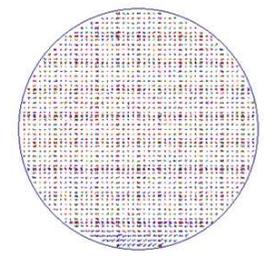
High performance optics enable to measure several marks

Alignment Accuracy: Repeatability & Reproducibility

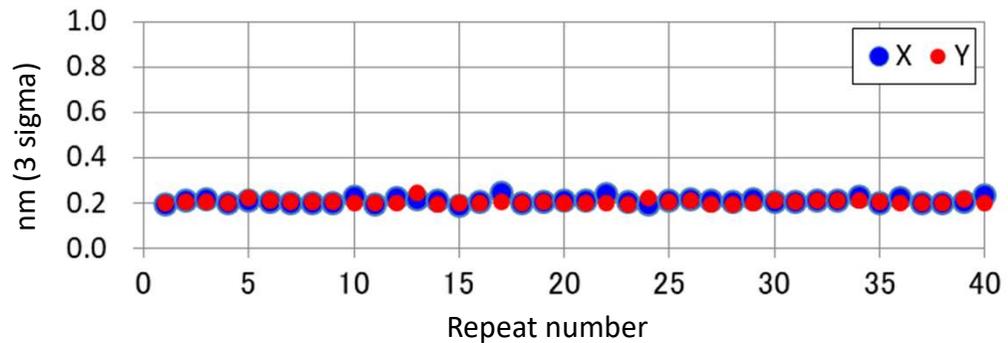


Measurement repeatability (3 sigma), 40 times

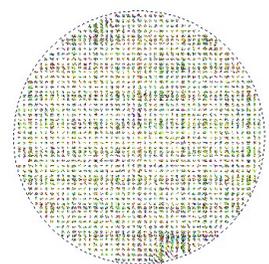
Alignment repeatability
2740 marks / wafer
(35 marks / field)
without
chuck / de-chuck



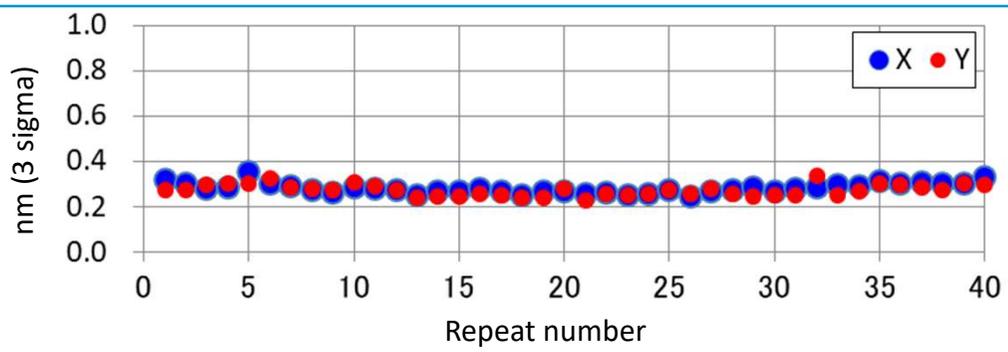
0.21 nm, 0.21 nm



Chucking reproducibility
2740 marks / wafer
(35 marks / field)



0.28 nm, 0.27 nm



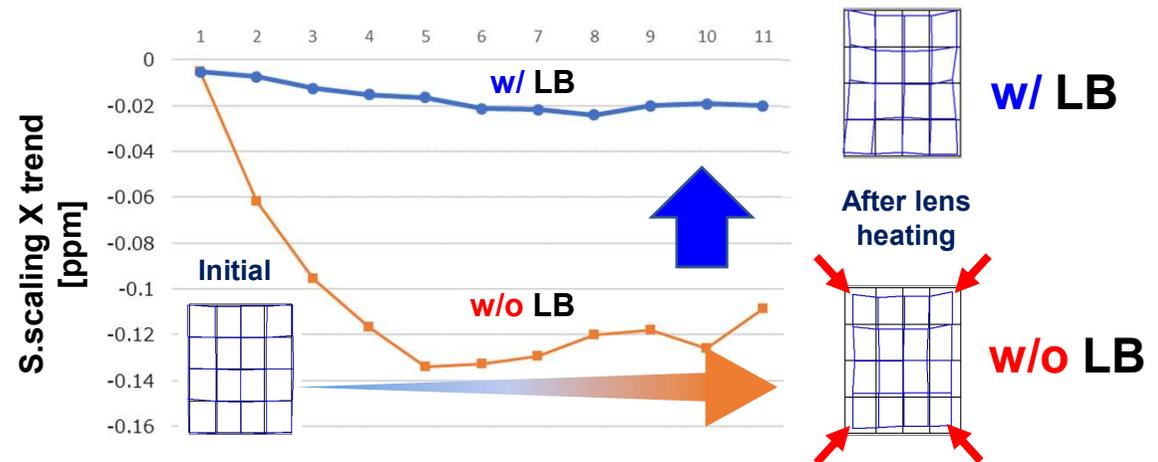
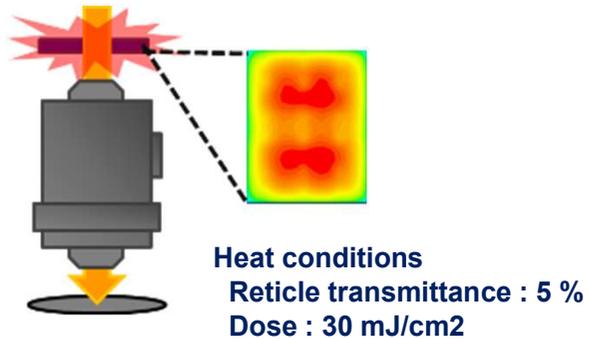
Excellent measurement accuracy with dense sampling

Scanner finger print correction



- Various scanners have own finger print
(grid, distortion, optics heating, reticle heating, wafer heating, pericle deformation)

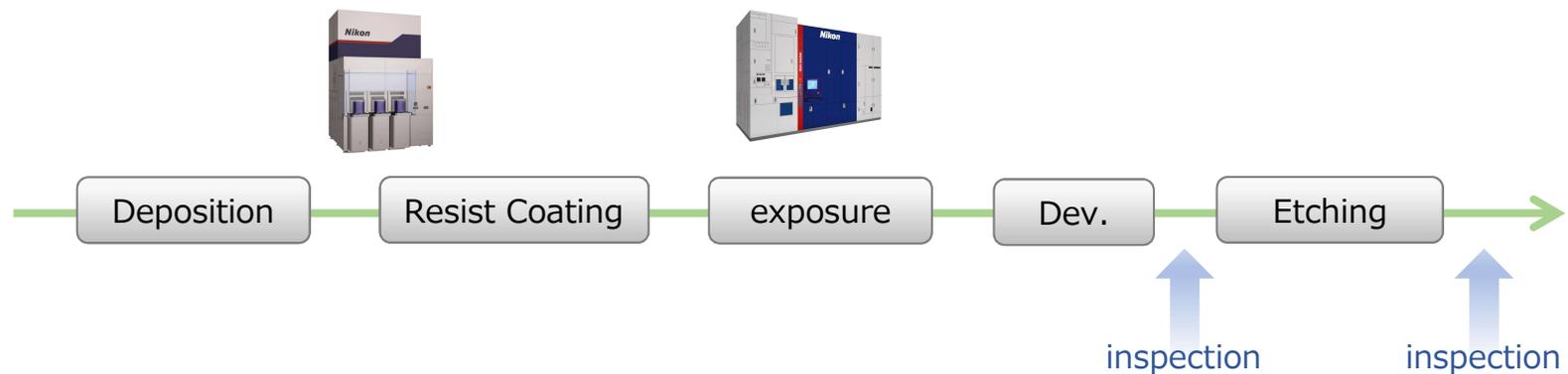
Reticle heating error



Yield management

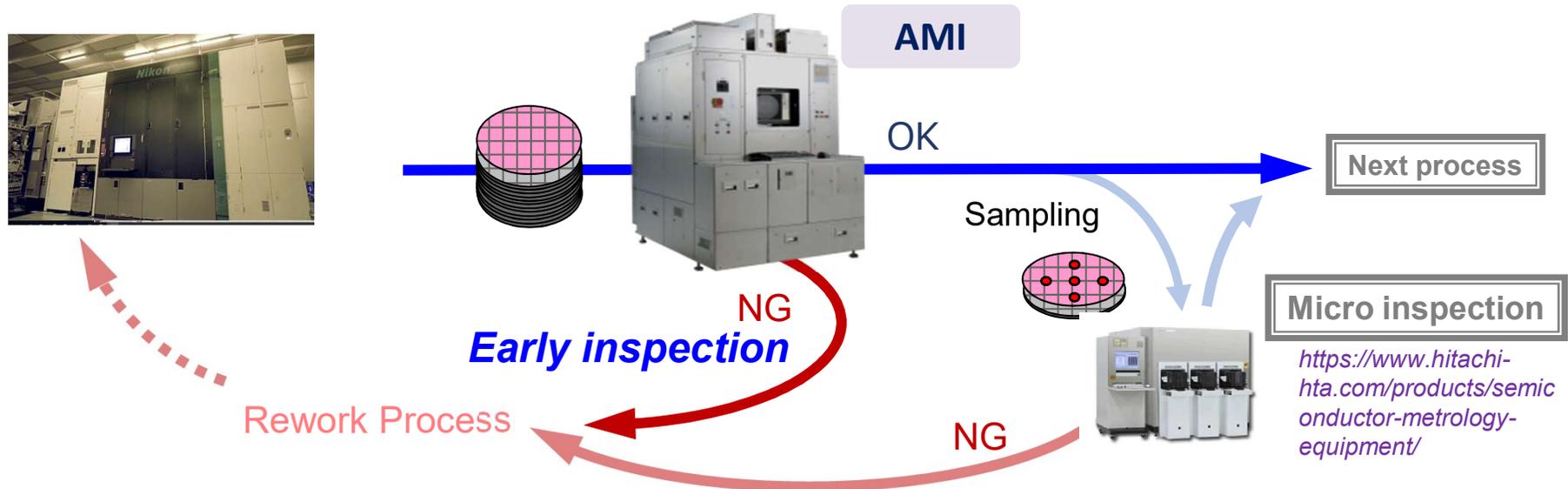


- iAS and Litho Booster enhance OPO by feedforward correction with dense sampling, and as the result contributes to the improvement of yield.
- From the viewpoint of yield, it is very important to maintain and improve production process by finding abnormalities in each production process.



- The important thing is that each inspection should not impact productivity.

Auto Macro Inspection



- Higher sensitivity imaging system
- Whole wafer detection system
- 170 wph
- Focus and dose inspection for Litho.
- Litho. coating inspection
- Particle & scratch inspection for wafer handling

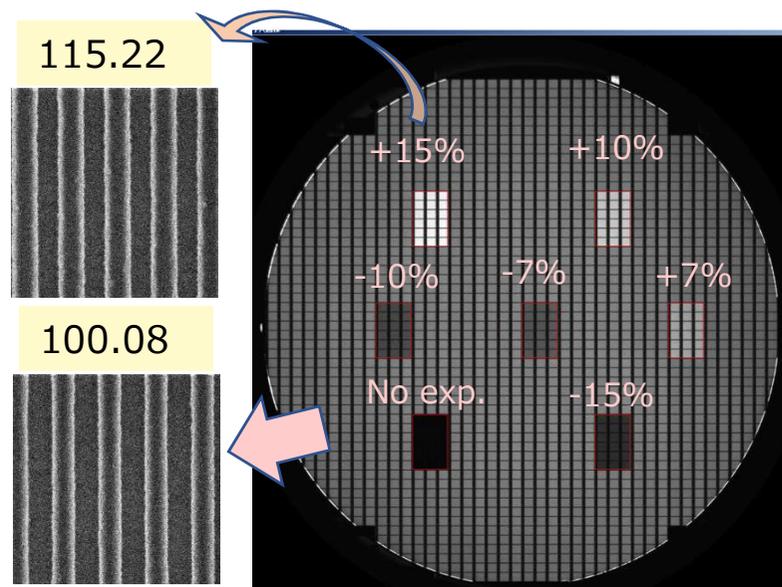
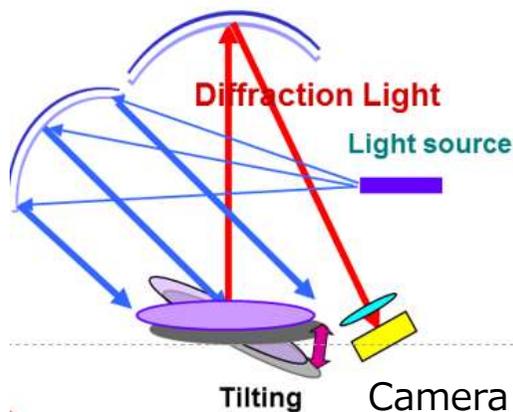
Early inspection will be important for the yield management

Higher sensitivity : Pattern dimension



Bright field for wafer pattern

Diffraction detection system



Abnormal pattern dimension (100 nm L/S)
→ ±15% dimension change can be detected

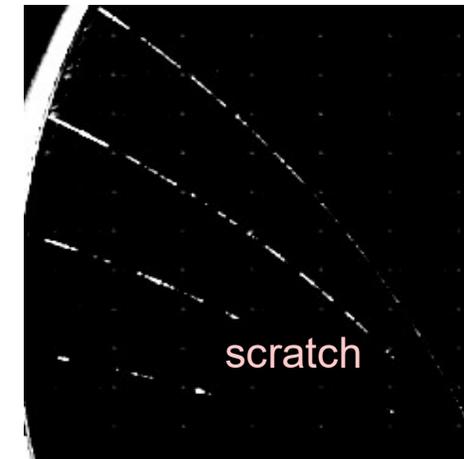
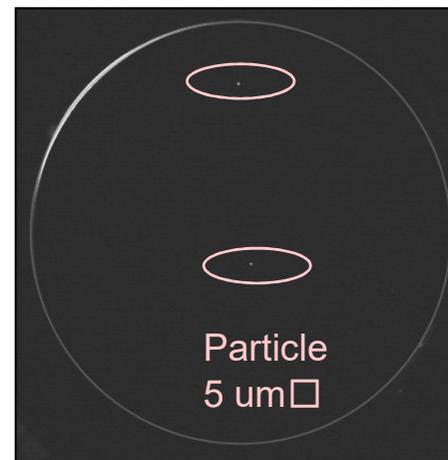
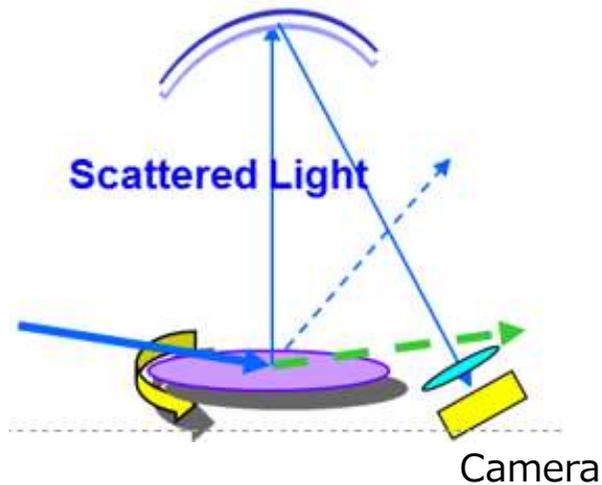
AMI can detect abnormal pattern dimension with higher throughput

Higher sensitivity : Particle detect



Dark field for particle/scratch

Scattering detection system



AMI enable yield management without productivity loss due to higher throughput by whole wafer surface observation

Summary



- Today, most important subject for IC manufacturing is On-product overlay improvement, corresponding to the scaling of devices, and wafer distortion of 3D structures.
- iAS and Litho Booster enhance On-product overlay by various correction with dense sampling and feed-forward alignment
- AMI enables more efficient process yield management with higher productivity





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