Photolithography Alignment Mark Transfer System For Low Cost Advanced Packaging and Bonded Wafer Applications

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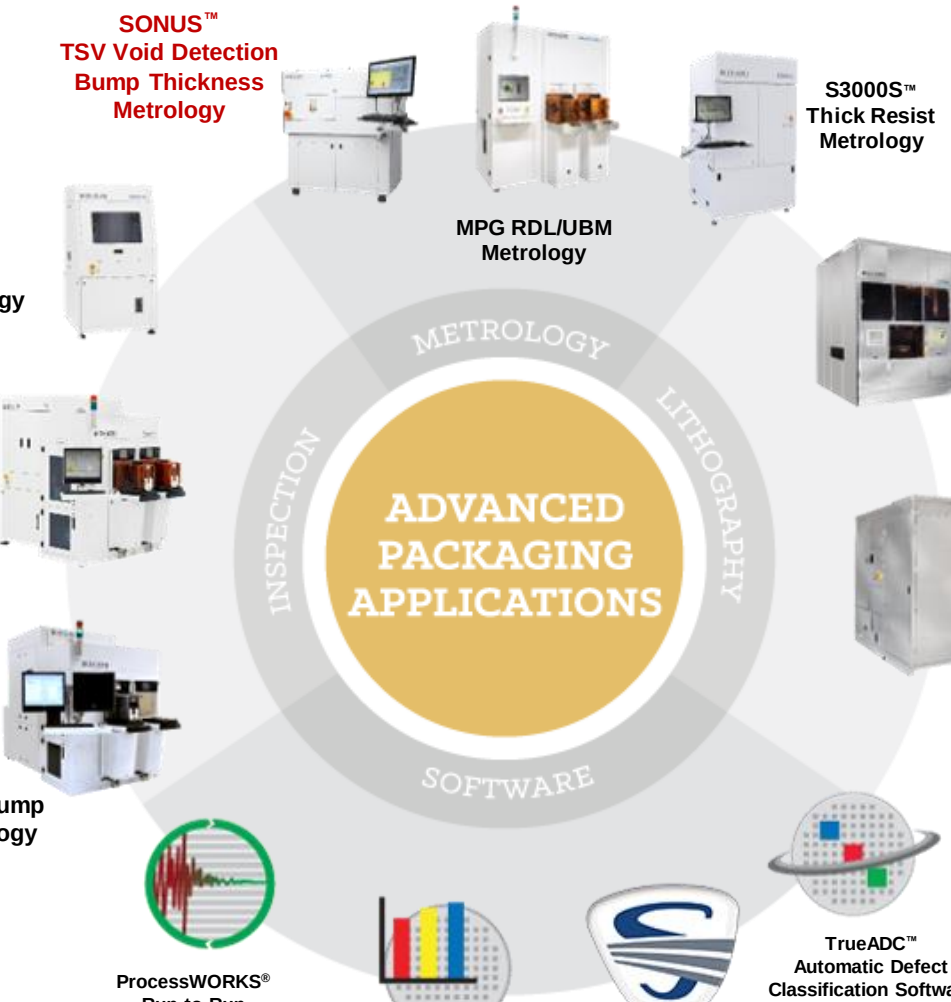
RUDOLPH TECHNOLOGIES

Outline

- Introduction
- Advanced Packaging Backside Alignment challenges
- JetStep specifications
- Align Mark Transfer System (AMTS) solution
- Proof of concept
- Overlay results
- Summary

Rudolph's Advanced Packaging Product Family



SONUS™
TSV Void Detection
Bump Thickness
Metrology

MPG RDL/UBM
Metrology

S3000S™
Thick Resist
Metrology

NSX®
2D Inspection
RDL / TSV Metrology

JetStep® S Series
Lithography System
(rectangular substrates)

NEXT GEN
RDL / TSV Metrology

JetStep® W Series
Lithography System
(wafer or round substrates)

WS 3880 3D Bump
Height Metrology

ProcessWORKS®
Run-to-Run
Control Software

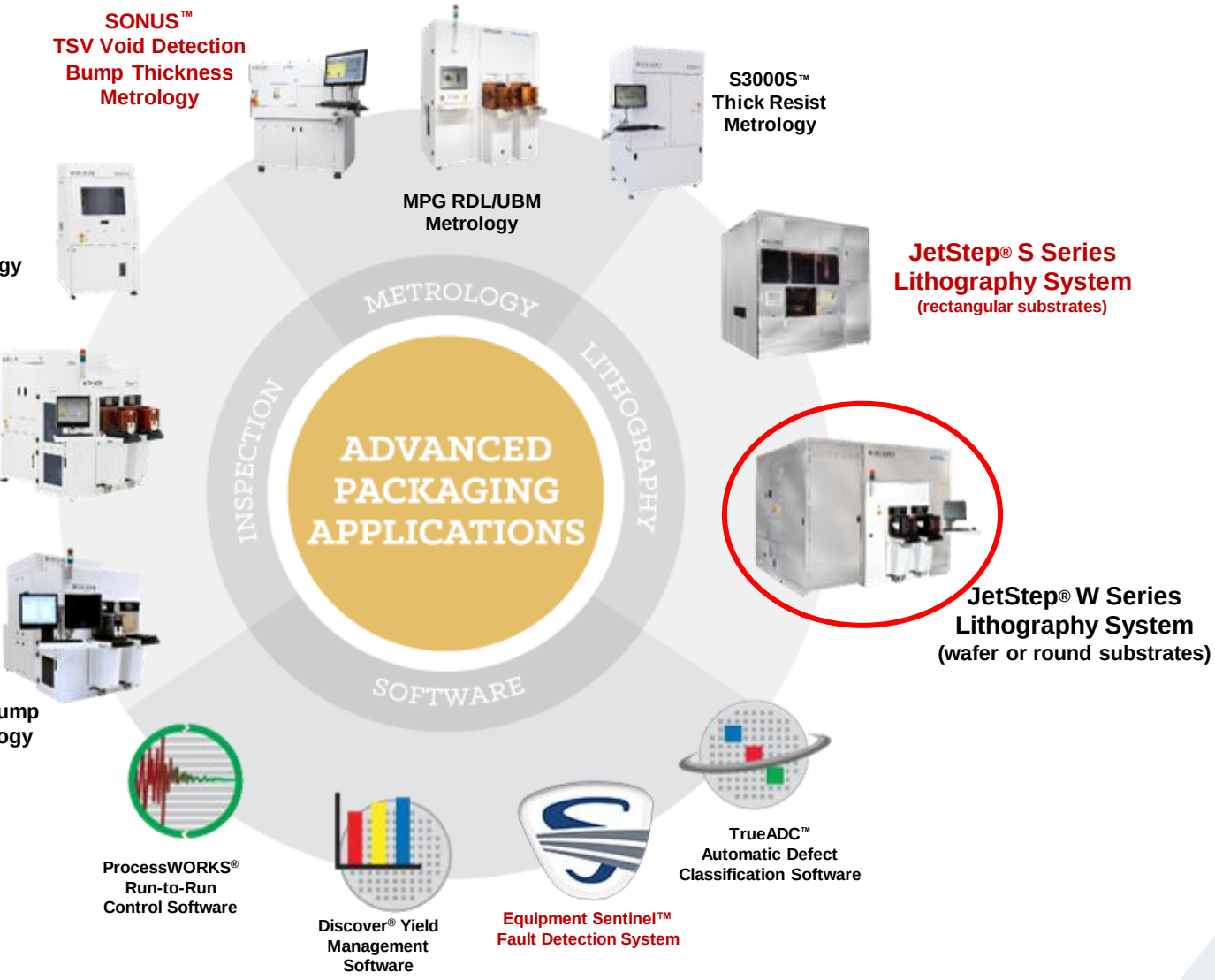
Discover® Yield
Management
Software

Equipment Sentinel™
Fault Detection System

TrueADC™
Automatic Defect
Classification Software

New Tools in 2015

Rudolph's Advanced Packaging Product Family



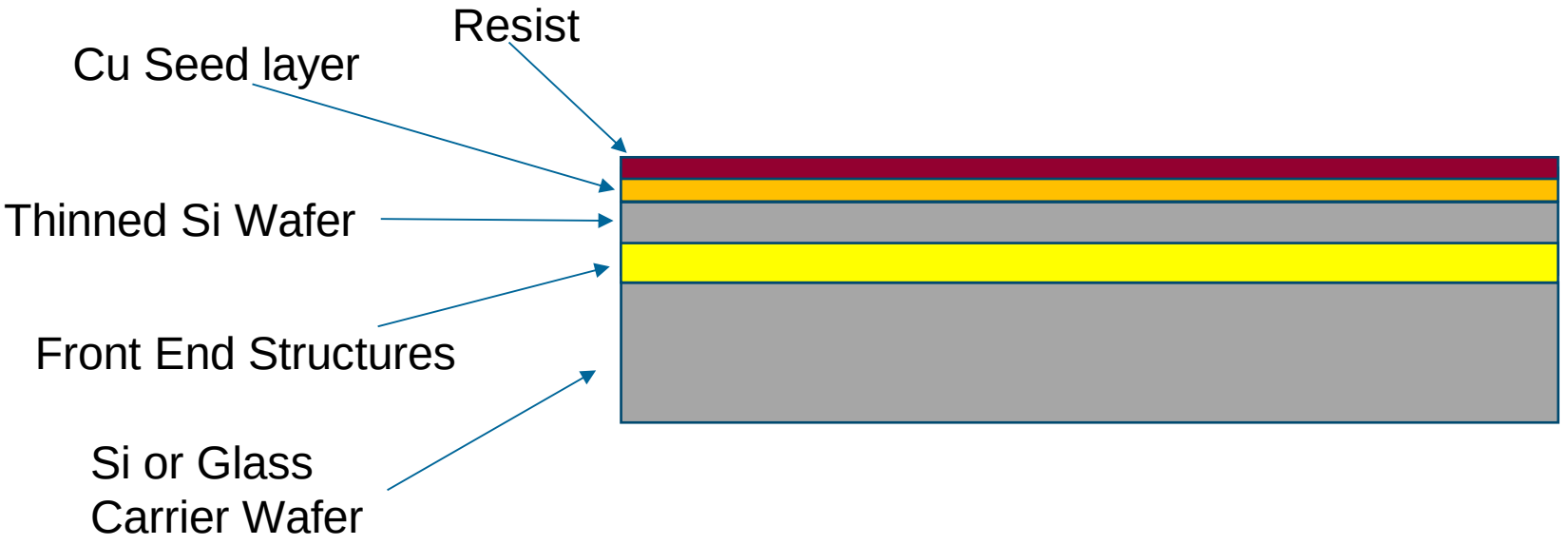
New Tools in 2015

Introduction

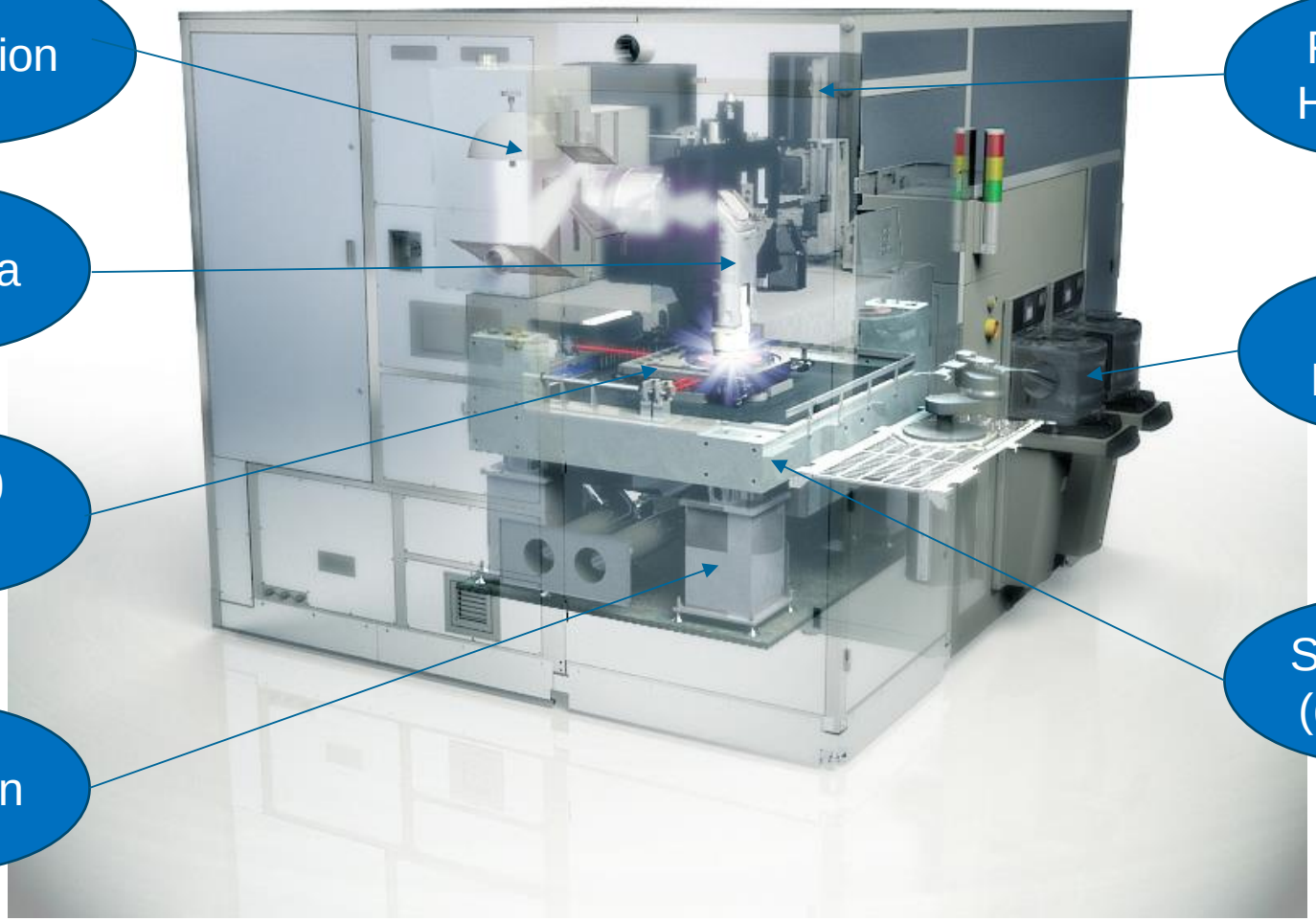
- Rudolph's Lithography Systems Group (LSG) develops and manufactures lithography systems (Steppers) for high volume production Advanced Packaging and FPD markets
- >25 years of experience building HVM lithography steppers
- Well developed supply chain
- Large IP portfolio

AP Back side alignment challenges

- Front end structures are not visible through Copper seed layer
- Current IR solutions are not suitable for HVM
  - Most have fixed optics requiring rigid alignment mark positions
  - Require additional processing steps impacting COO



JetStep System Internal Overview

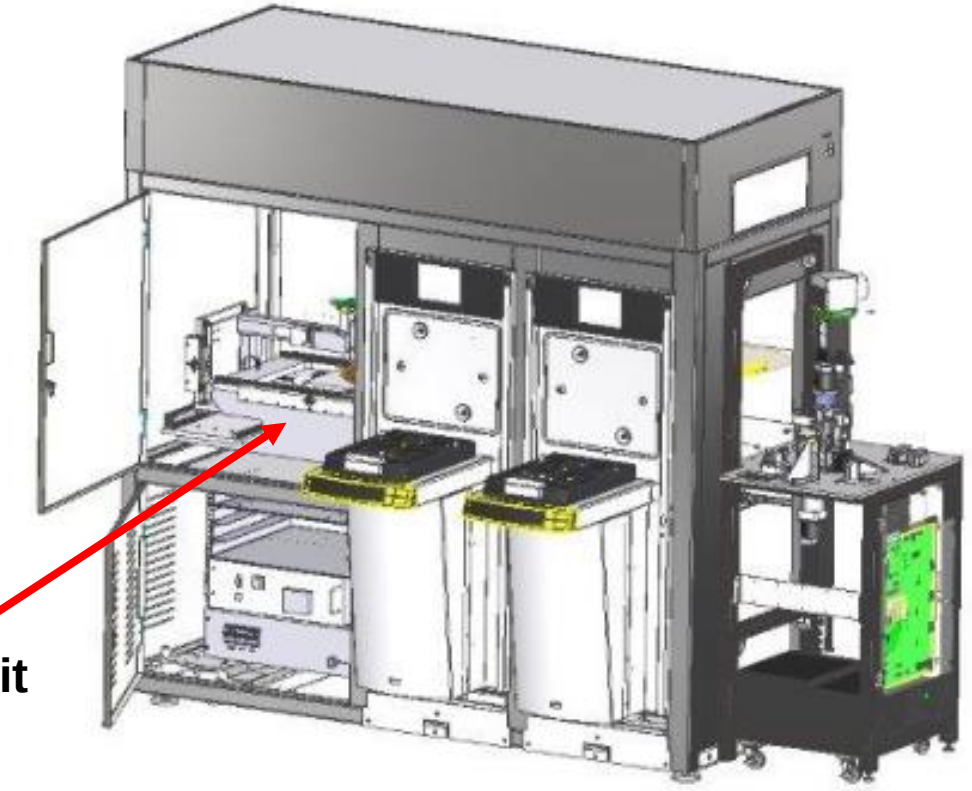


JetStep Specifications

Wafer size	200mm, 300mm, 300+, Panels
Optics	2X reduction
Working distance	17mm
Exposure Field Size	59.4mm x 59.4mm, 52mm x 66mm
NA	0.10
Resolution	2µm L/S (i-line), 3µm L/S (ghi)
Wavelengths	ghi, gh, i
System Overlay	Mean + 3sigma <0.5um
AMTS Overlay	<2µm

AMTS Module

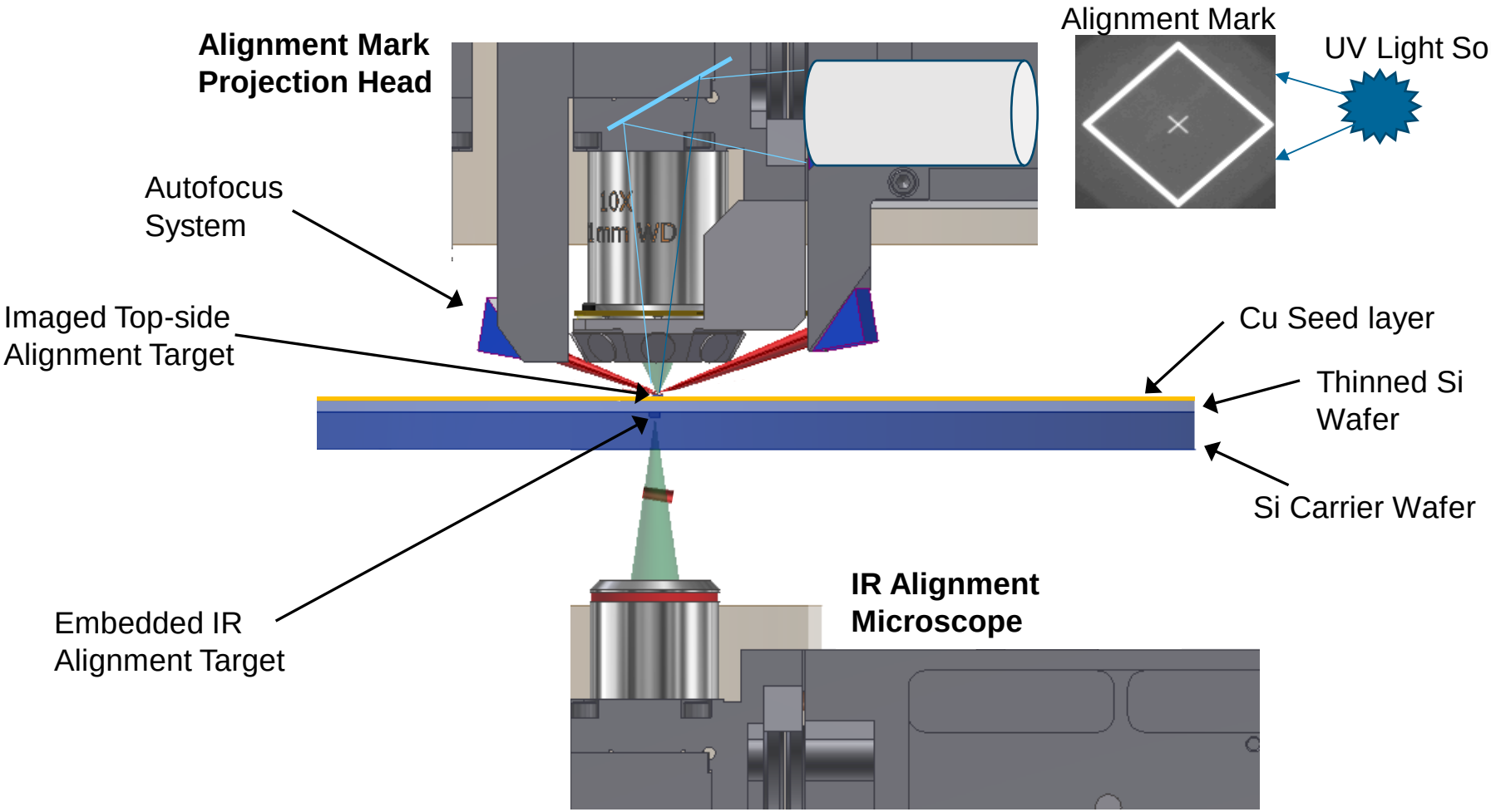
- *Located at a separate station within the stepper to enable parallel operations*
- *Stage provides Alignment mark placement anywhere on the wafer*



Concurrent alignment transfer and exposure operations

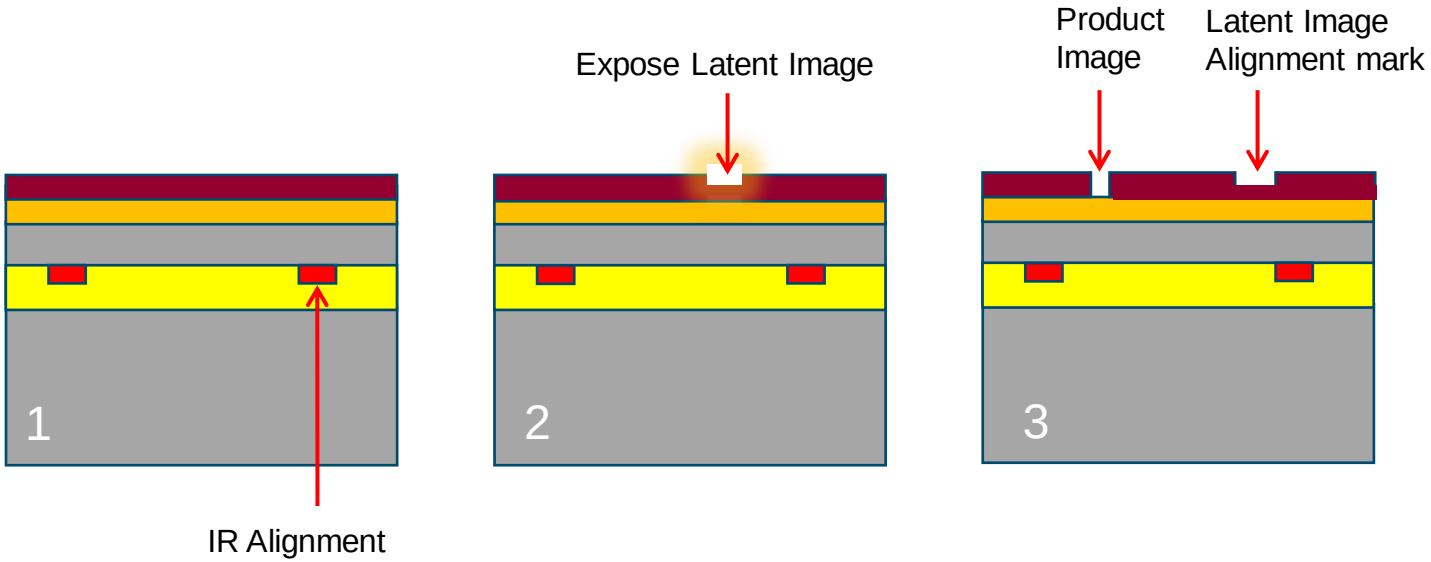
No throughput impact.

Alignment Mark Transfer System (AMTS) - Solution

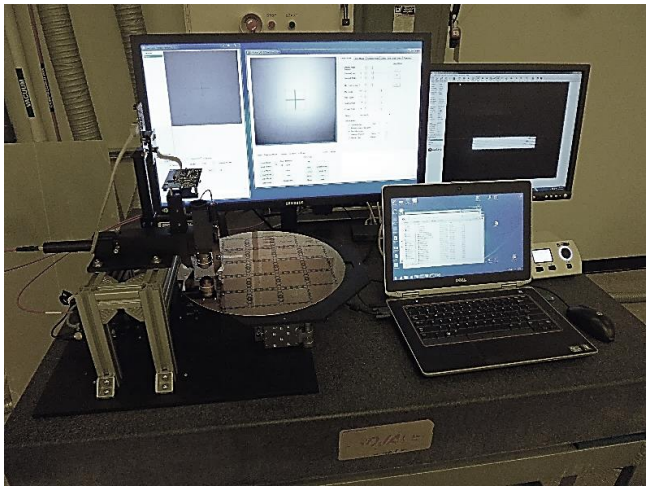


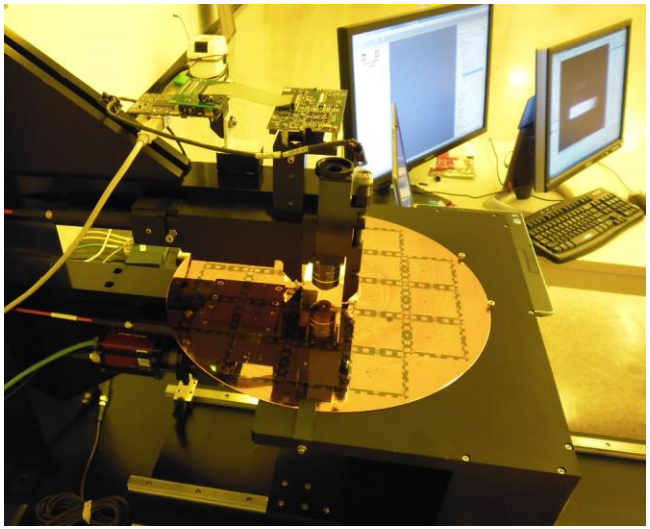
AMTS Process flow

1. AMTS aligns using IR camera to buried alignment marks
2. AMTS exposes latent image alignment marks on top side of wafer
3. Stepper aligns to latent image marks and prints product layer



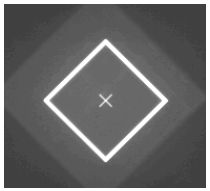
Proof of Concept Apparatus





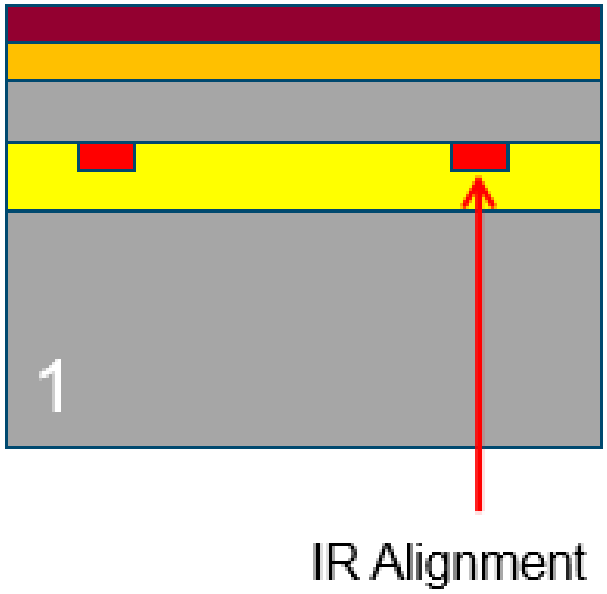
- Etched Copper seed wafer with alignment marks
- IR alignment up through the back of the wafer

- Projected alignment mark imaged in resist on top side of wafer to evaluate mark transfer performance

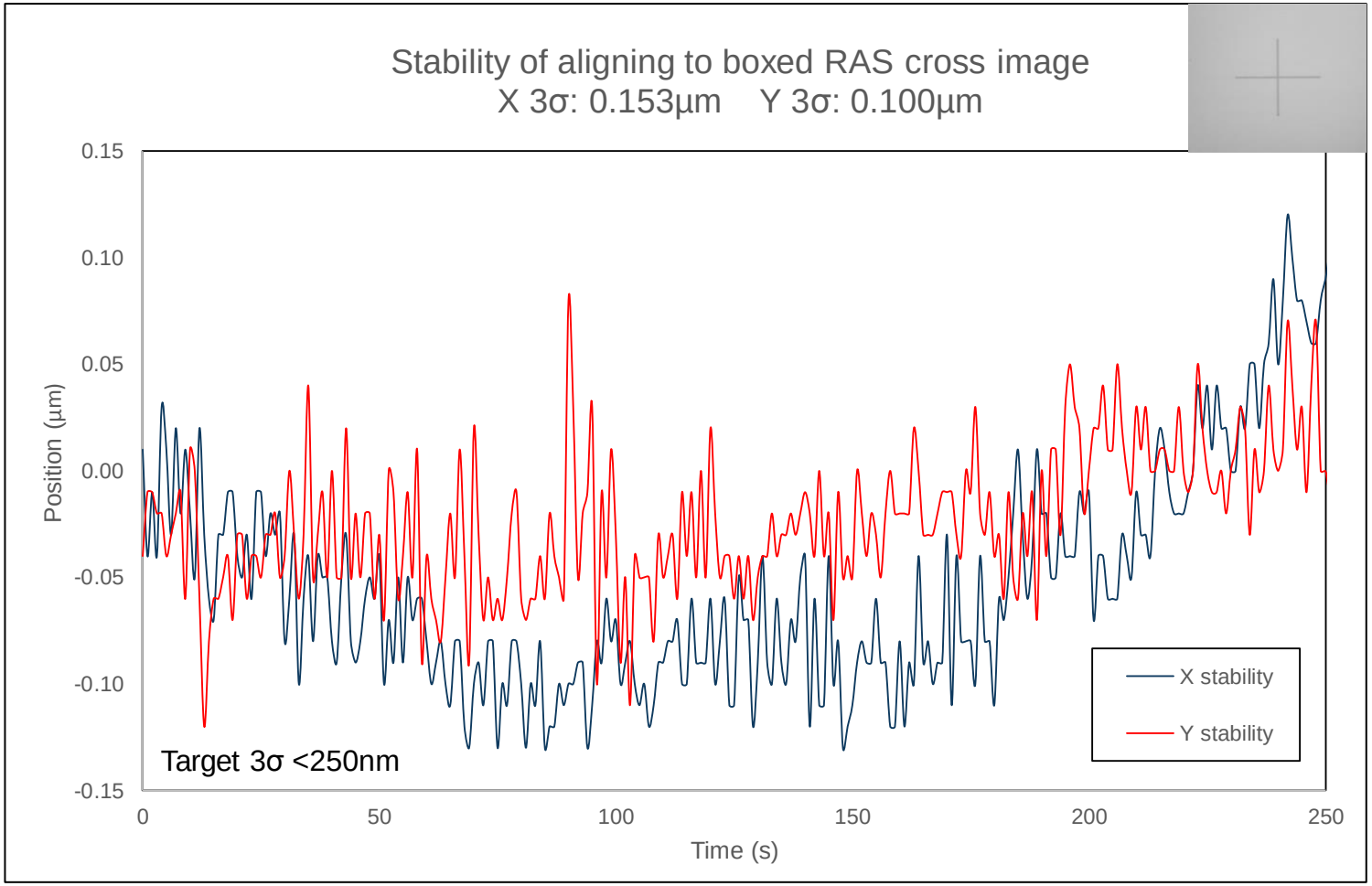


AMTS Process flow

1. AMTS aligns using IR camera to buried alignment marks

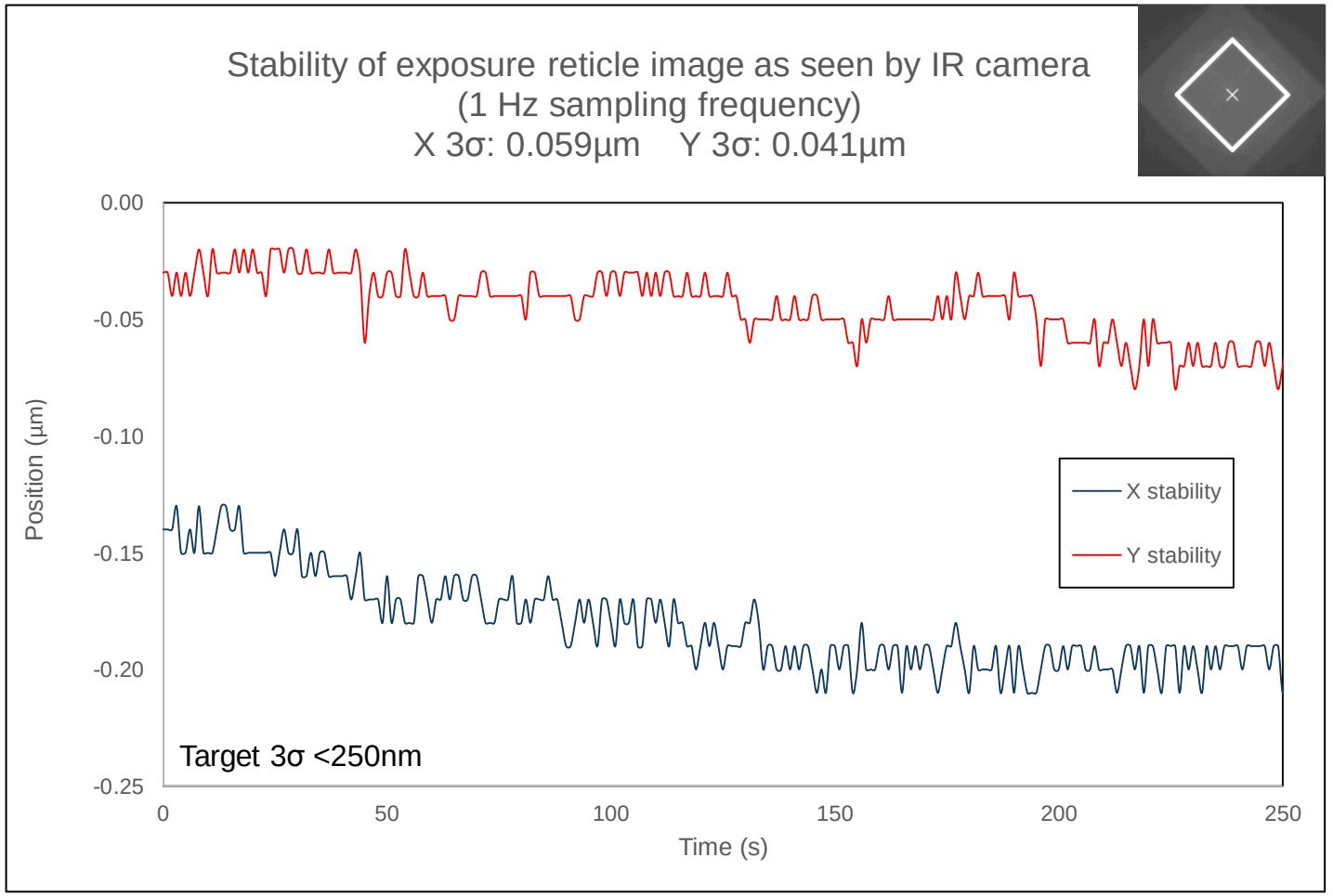


Alignment to copper target with IR camera



IR Alignment Repeatability <200nm 3σ

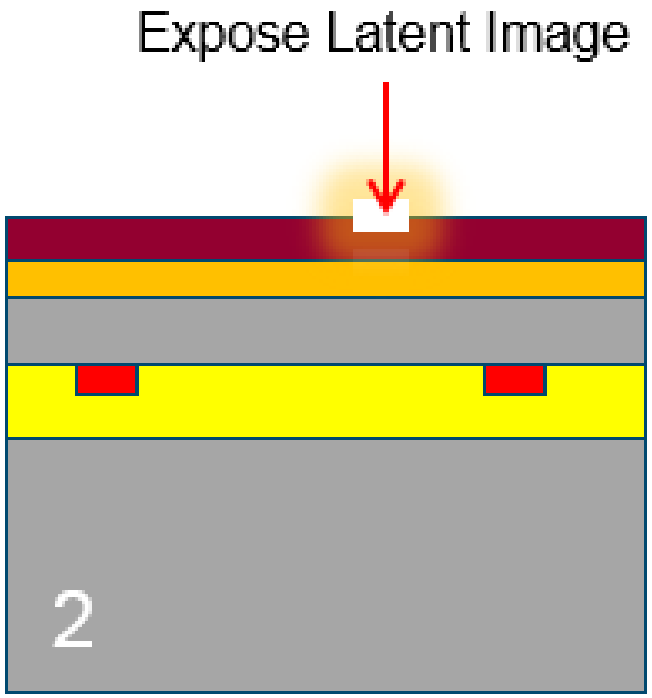
Alignment stability of projected image



Projected Image Stability <100nm 3σ

AMTS Process flow

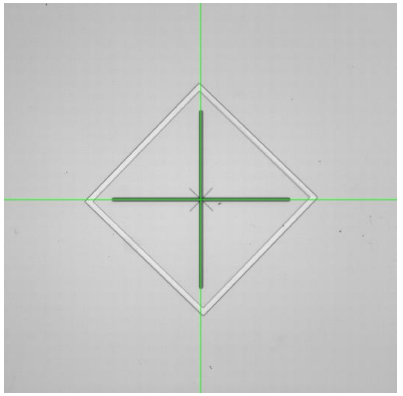
2. AMTS exposes latent image alignment marks on top side of wafer



- After latent image exposure, the stepper aligns to the latent images and exposes the product pattern on the wafer

Alignment mark transfer accuracy & precision

- 12 alignment marks transferred to resist on copper seed surface and developed
- Stepper automated metrology confirmed good accuracy and precision



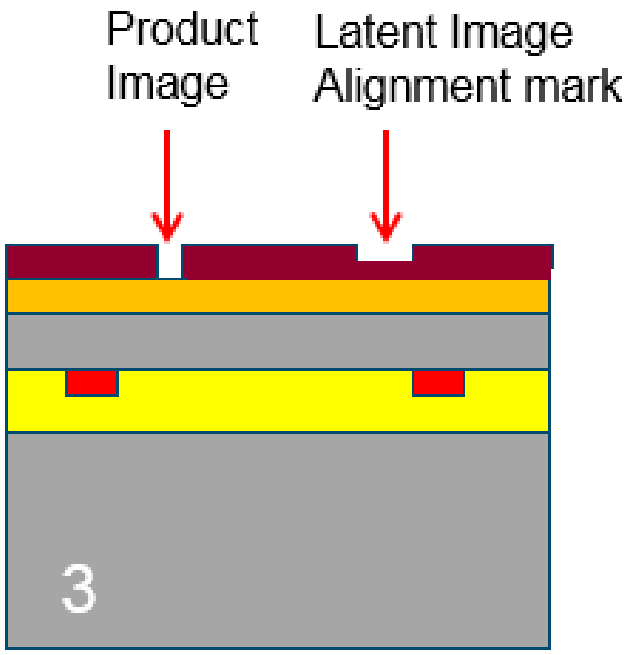
	Location on Silicon wafer											
Registration	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
X (µm)	-0.65	-0.76	-0.83	-0.42	-0.36	0.07	0.25	0.10	0.04	-0.07	-0.13	-0.25
Y (µm)	-0.26	-0.10	-0.10	0.56	0.40	-0.17	-0.26	-0.11	-0.02	-0.59	-0.53	-0.37
Vector	0.70	0.77	0.84	0.70	0.54	0.18	0.36	0.15	0.04	0.59	0.55	0.45

Accuracy		**Precision**			
Mean X (µm)	-0.25	**3 Sigma X**	1.07	**Max Vector**	0.84µm
Mean Y (µm)	-0.13	**3 Sigma Y**	1.01		

Max X,Y error vector 0.84um

AMTS Process flow

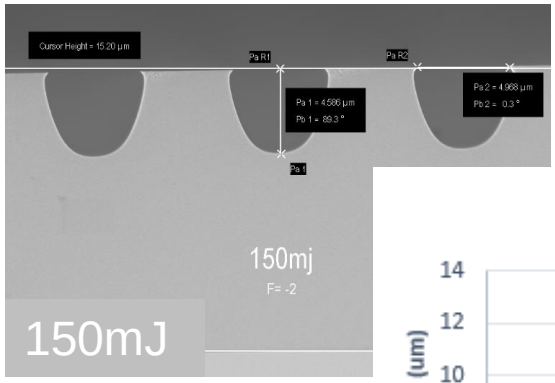
3. Stepper aligns to latent image marks and prints product layer

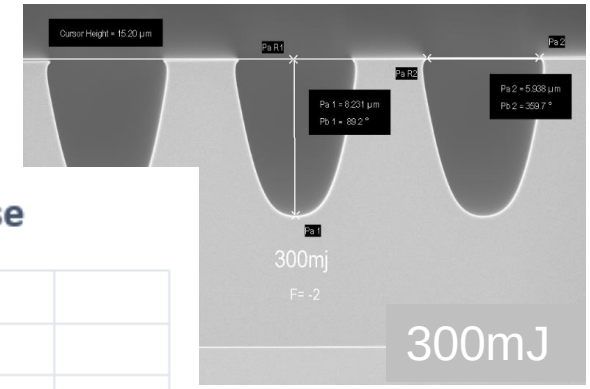


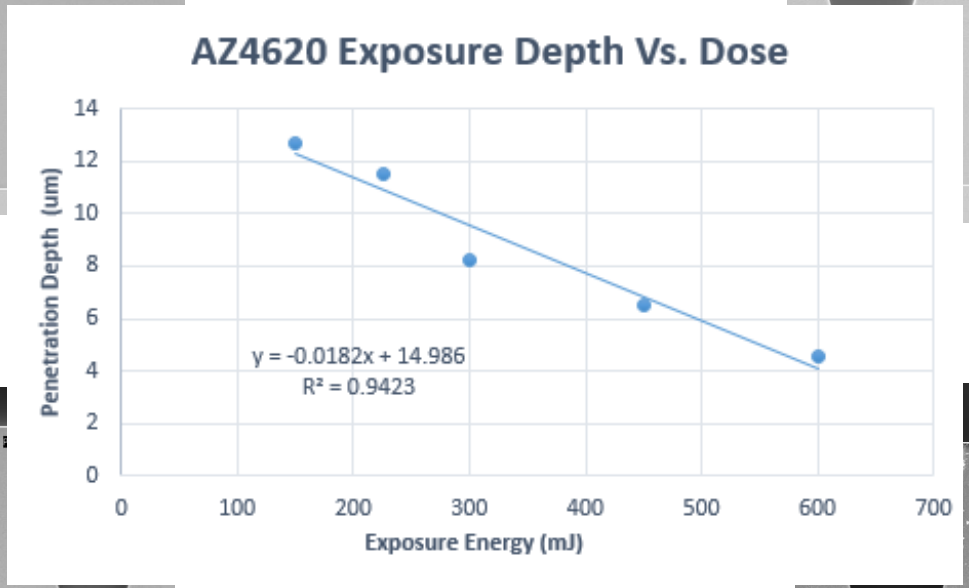
- After development of the wafer the latent image alignment marks must not penetrate through the resist to the copper seed layer, otherwise they will be plated and become defects
- AZ 4620 resist provides good latent images at low dose and the penetration depth is well controlled
- The penetration depth is linear with dose

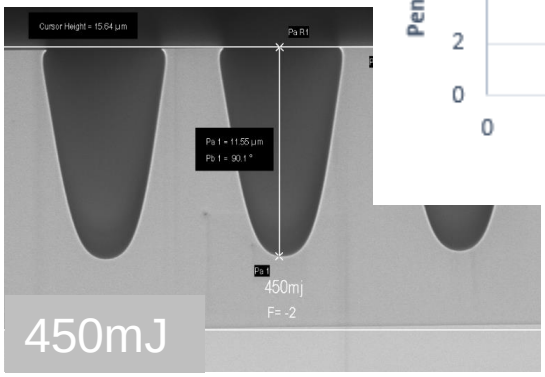
Latent Image Cross Section after Develop

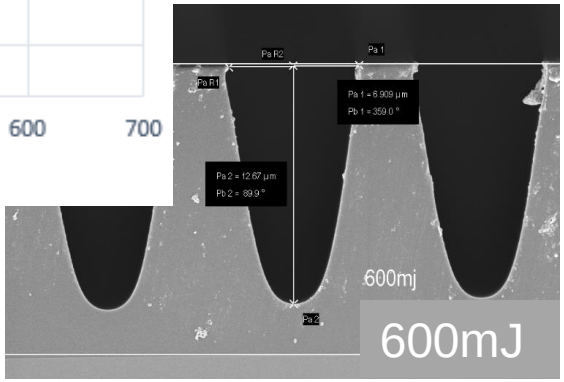
- AZ4620 15um FT cross sectional images as a function of dose







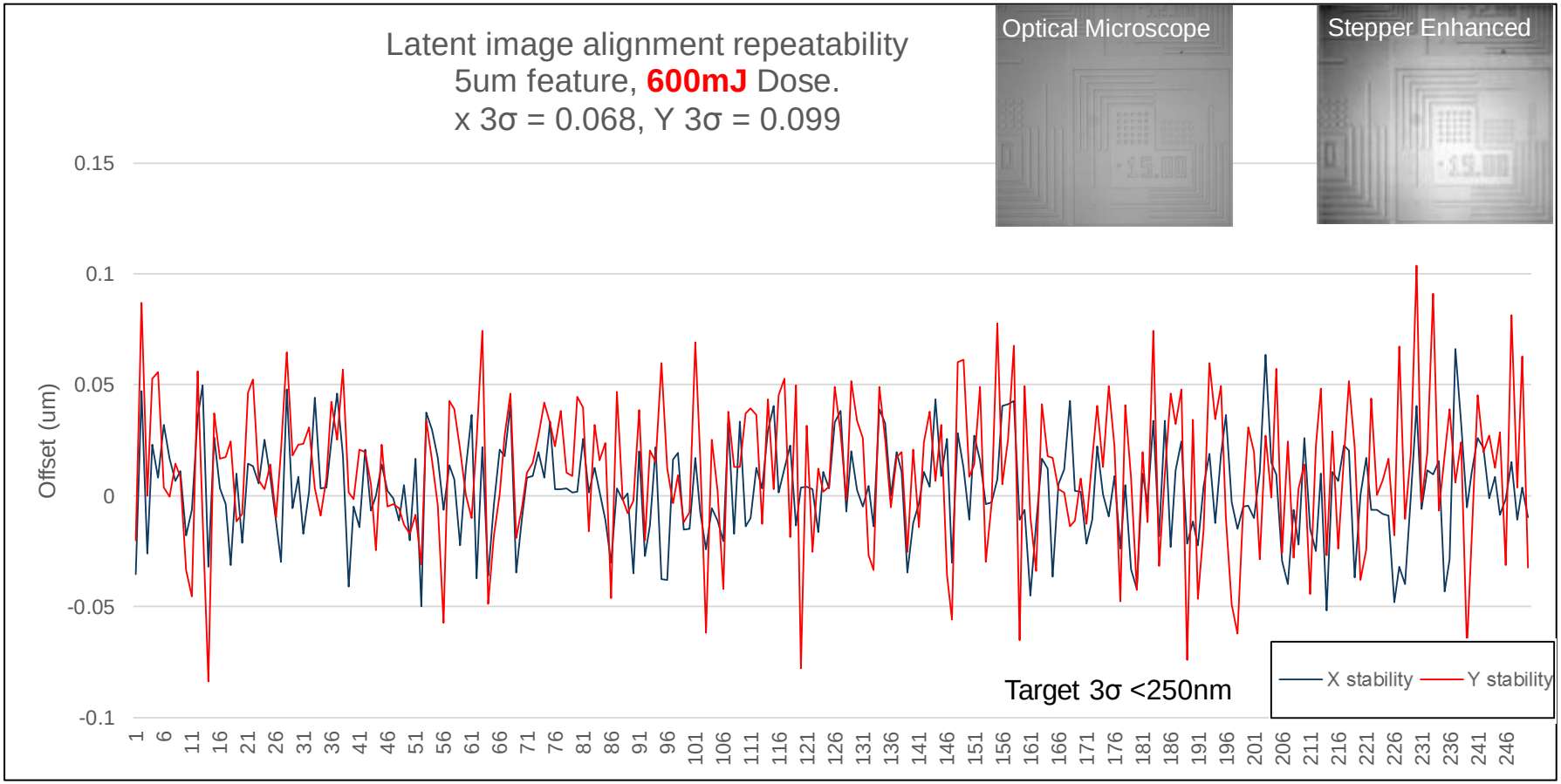




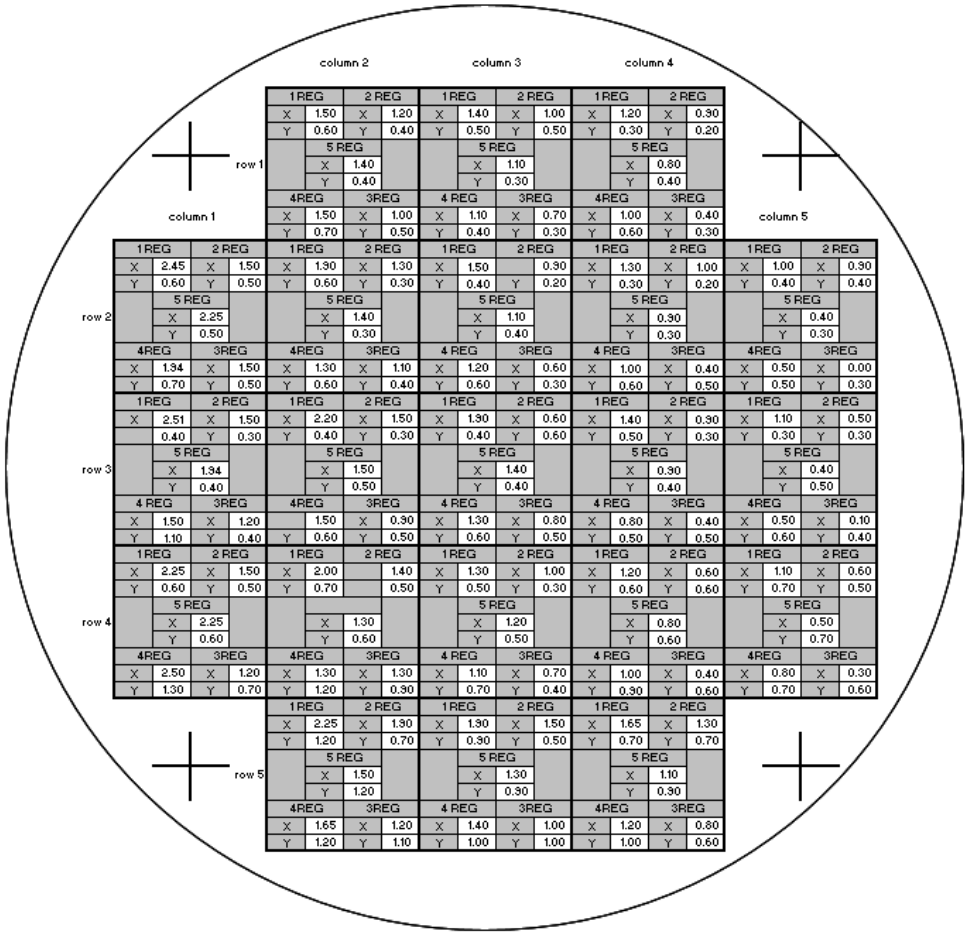
Good exposure latitude for not penetrating through resist

Latent Image Alignment

- Latent image marks in AZ4620, 5um features in 15um thick resist

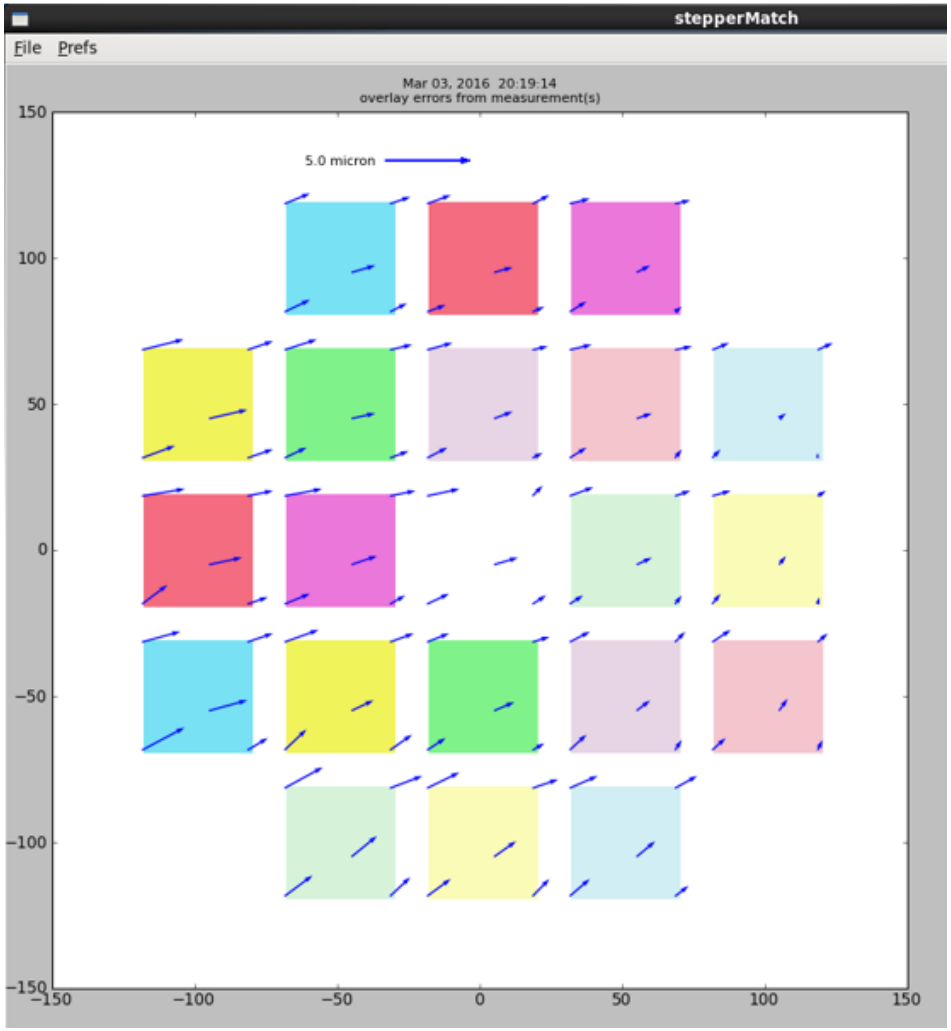


Overlay Results – Optical Vernier Measurements

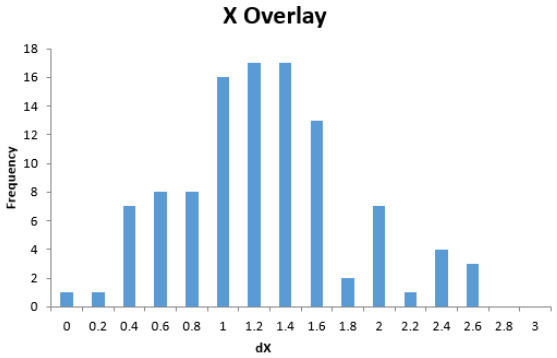


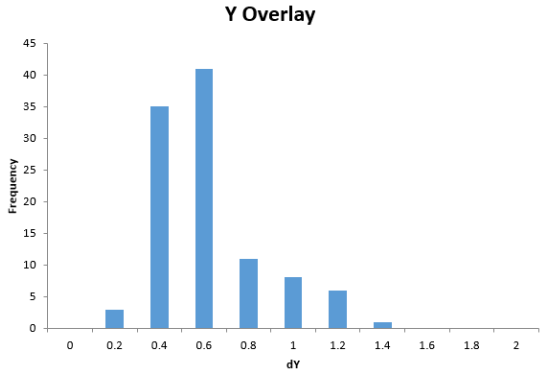
- JetStep alignment to 5 latent image alignment targets
- Overlay measurements at 5 points per field

Raw Data



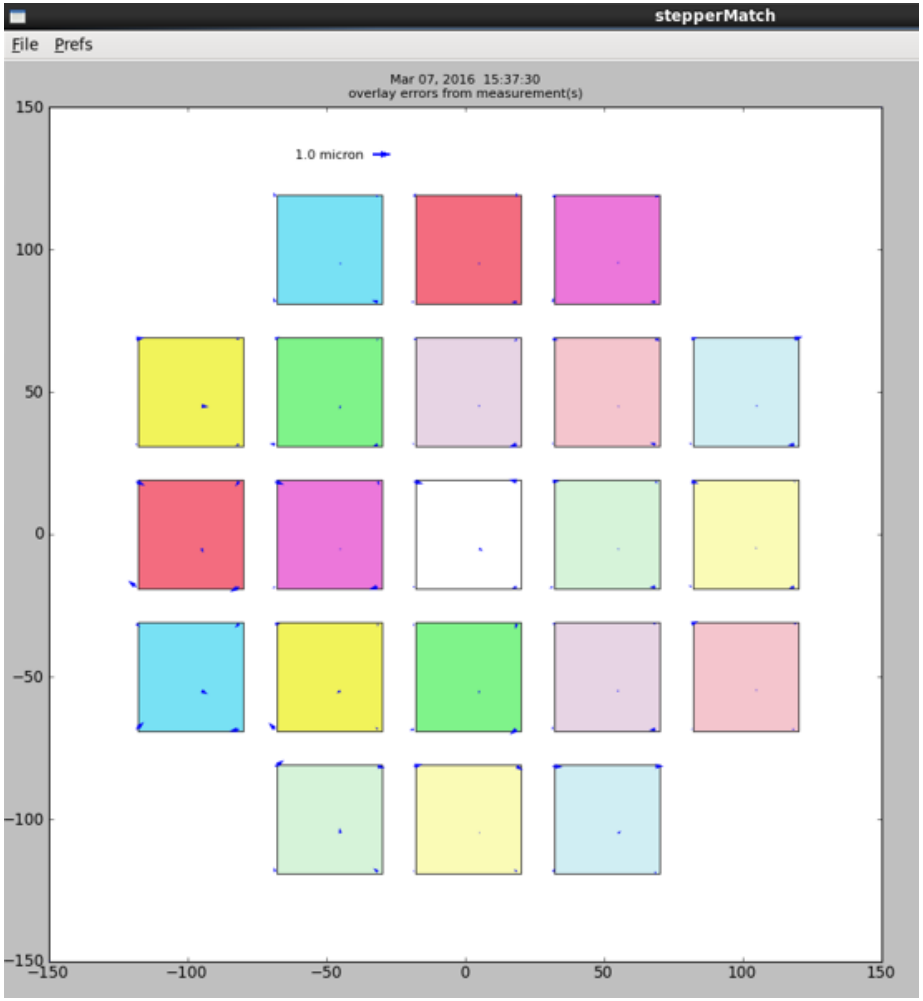
- Vernier data converted to wafer vector plot and histograms





	n pts	max	min	std dev	avg	mean+3sig
X	105	2.510	0.000	0.530	1.200	2.792
Y	105	1.300	0.200	0.245	0.561	1.296

After Stepper Corrections



- After adjusting the stepper correctable parameters final overlay result <1um

	n pts	max	min	std dev	avg	mean+3sig
X	105	0.606	-0.586	0.297	-0.000	0.891
Y	105	0.439	-0.318	0.166	-0.000	0.497

AMTS Summary

- Projected Image Alignment Stability **3σ <100nm**
- Alignment repeatability **3σ <150nm** using IR microscope through 750µm Si to Cu structures
- Alignment mark transfer precision **3σ <1.1µm**
- Latent image alignment repeatability on stepper **3σ <200nm**
- Good exposure latitude for latent images without breaching the photoresist to the Copper seed layer
- Final Overlay performance prediction after stepper corrections **<1µm**
- Ready to begin customer process evaluations to demonstrate production capability.

Acknowledgments

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Mr. Anthony Fill – Mechanical Engineer

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Mr. Salwan Omar – RIT Intern

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谢谢 | 謝謝

danke

ありがとう

Thank You!

감사합니다

merci

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