PROCESS CONTROL AND APPLIEDPRO™ MASTER CLASS

October 18, 2021

Forward-Looking Statements and Other Information

Today's presentations contain forward-looking statements, including those regarding anticipated growth and trends in our businesses and markets, industry outlooks and demand drivers, technology transitions, our business and financial performance and market share positions, our capital allocation and cash deployment strategies, our investment and growth strategies, our development of new products and technologies, our business outlook for the fourth quarter of fiscal 2021 and beyond, the impact of the ongoing COVID-19 pandemic and responses thereto on our operations and financial results, and other statements that are not historical facts. These statements and their underlying assumptions are subject to risks and uncertainties and are not guarantees of future performance.

Factors that could cause actual results to differ materially from those expressed or implied by such statements include, without limitation: the level of demand for our products, our ability to meet customer demand, and our suppliers' ability to meet our demand requirements; global economic and industry conditions; the effects of regional or global health epidemics, including the severity and duration of the ongoing COVID-19 pandemic; global trade issues and changes in trade and export license policies, including rules and interpretations promulgated by U.S. Department of Commerce expanding export license requirements for certain products sold to certain entities in China; consumer demand for electronic products; the demand for semiconductors; customers' technology and capacity requirements; the introduction of new and innovative technologies, and the timing of technology transitions; our ability to develop, deliver and support new products and technologies; the concentrated nature of our customer base; acquisitions, investments and divestitures; changes in income tax laws; our ability to expand our current markets, increase market share and develop new markets; market acceptance of existing and newly developed products; our ability to obtain and protect intellectual property rights in key technologies; our ability to achieve the objectives of operational and strategic initiatives, align our resources and cost structure with business conditions, and attract, motivate and retain key employees; the variability of operating expenses and results among products and segments, and our ability to accurately forecast future results, market conditions, customer requirements and business needs; and other risks and uncertainties described in our SEC filings, including our recent Forms 10-Q and 8-K. All forward-looking statements are based on management's current estimates, projections and assumptions, and we assume no obligation to update them.

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make possible

2021 Master Classes

WELCOME

Michael Sullivan
Corporate Vice President
Head of Investor Relations

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2021 INVESTOR EVENTS

MASTER CLASSES

April 6	May 5	June 16	September 8	October 18
2021 Investor Meeting	Memory	Logic	ICAPS & Advanced Packaging	Process Control & AppliedPRO™

AGENDA

9:00	**PART 1**	HOST: Mike Sullivan Fireside Chat | Dan Hutcheson, CEO, Chairman, VLSIresearch
9:10	**PART 2**	HOST: Keith Wells Imaging and Process Control Group Introduction Process Diagnostics and Control | Maayan Bar-Zvi Process Optimization and Control | Lior Engel
9:40	**PART 3**	HOST: Keith Wells Imaging and Process Control Growth Opportunities
9:50	**Q&A**	Keith, Maayan, Lior, Mike

KEY Messages

1. Applied's Imaging and Process Control Group (IPC) includes Process Diagnostics and Control (PDC) and Process Optimization and Control (POC)

2. *Strategy:* Improve PPAC and accelerate "t" at Applied and for our customers

3. *Objective:* Drive profitable growth across Applied Materials and outperform the PDC market

FIRESIDE CHAT

Dan Hutcheson
CEO and Chairman
VLSIresearch, Inc.

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Imaging and Process Control Group Introduction

Keith Wells
Group Vice President, GM
Imaging and Process Control Group

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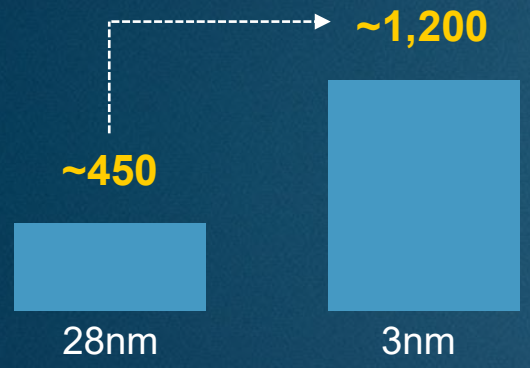
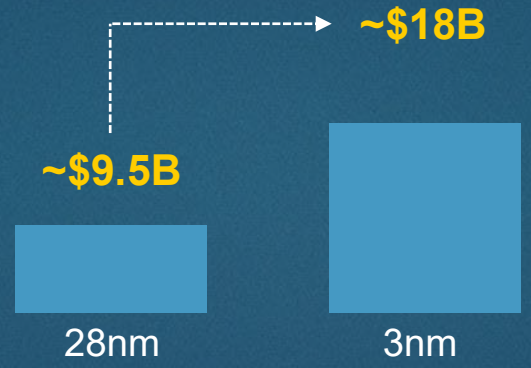
Semiconductor Manufacturing Company Challenges

Process Steps

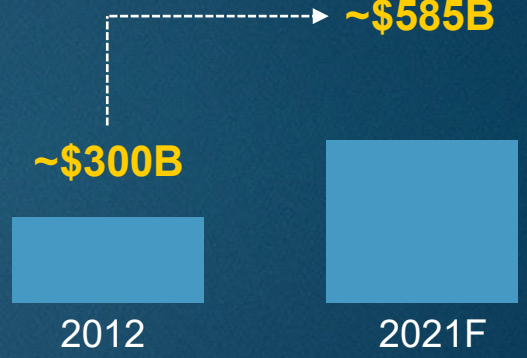


Equipment Cost*



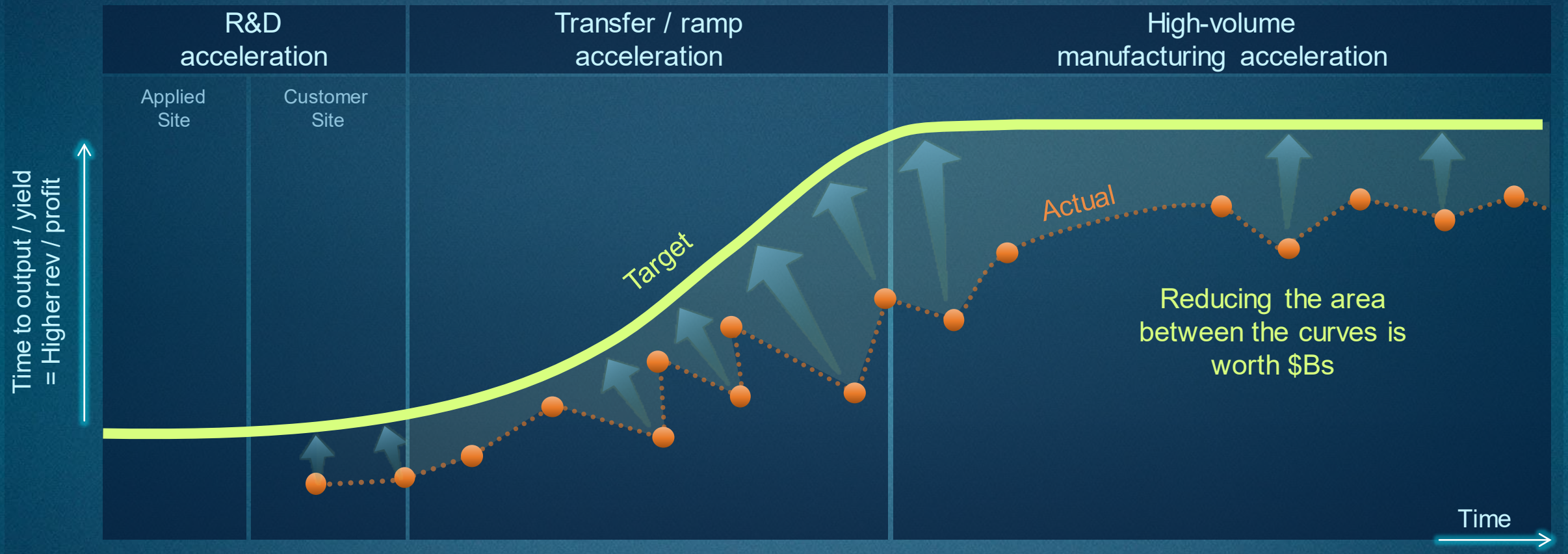
*100K WSPM Greenfield

Semiconductor Revenue



Source: VLSI, Applied Materials

The Value of “t” – Time-to-Market



Winning PPACt™ race is worth $billions to customers and the technology ecosystem

Source: Applied Materials

Applied Imaging and Process Control Group

Process Diagnostic and Control Group

eBeam

SEMVision®
Defect Review

PROVision®
eBeam Emerging Metrology

VeritySEM®
eBeam CD Metrology

Optical

Enlight®
Optical Wafer Inspection

Aera™
Optical Mask Inspection

PROCESS CONTROL AND APPLIEDPRO™

NEW PLAYBOOK FOR PATTERNING CONTROL

Maayan Bar-Zvi
Business Unit Head
Process Diagnostics and Control

Applied Imaging and Process Control Group

Process Diagnostic and Control Group

eBeam

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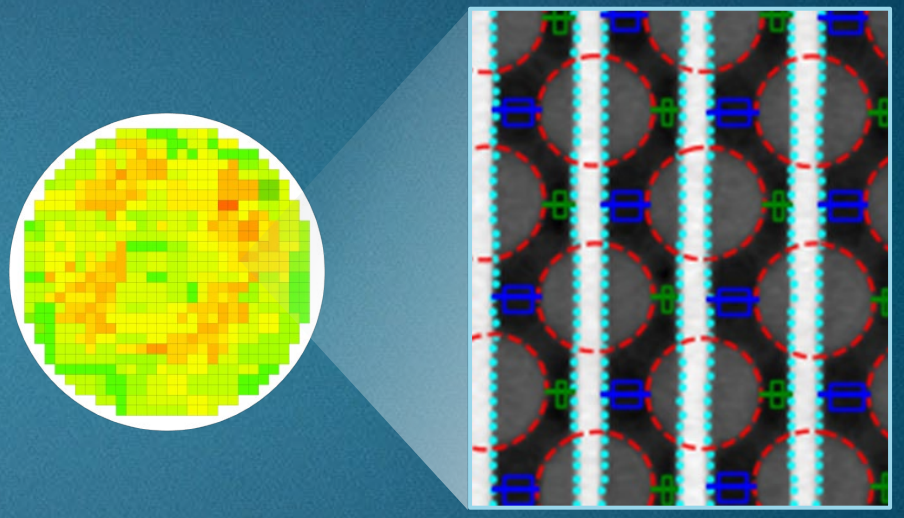
Process Optimization and Control Group



Co-optimized metrology

PROCESS CONTROL AND APPLIEDPRO™

NEW PLAYBOOK FOR PATTERNING CONTROL

Maayan Bar-Zvi
Business Unit Head
Process Diagnostics and Control

AppliedPRO™

Lior Engel
CVP, GM
Process Optimization and Control

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make possible

New Playbook for Patterning Control

Maayan Bar-Zvi
Business Unit Head
Process Diagnostics and Control

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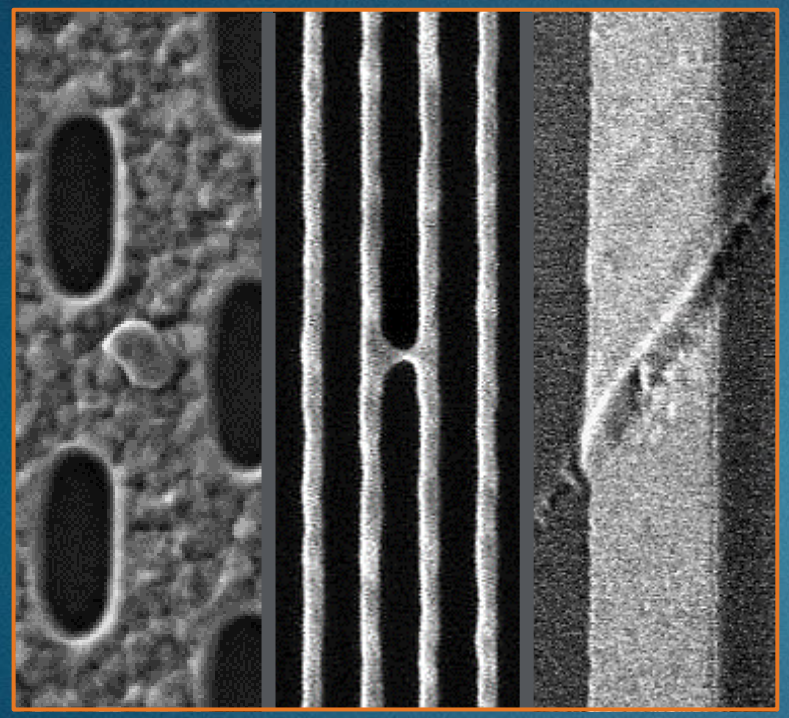
AGENDA

1. Critical role of patterning control
2. Patterning inflection point
3. New playbook for patterning control
4. New PROVision® 3E system

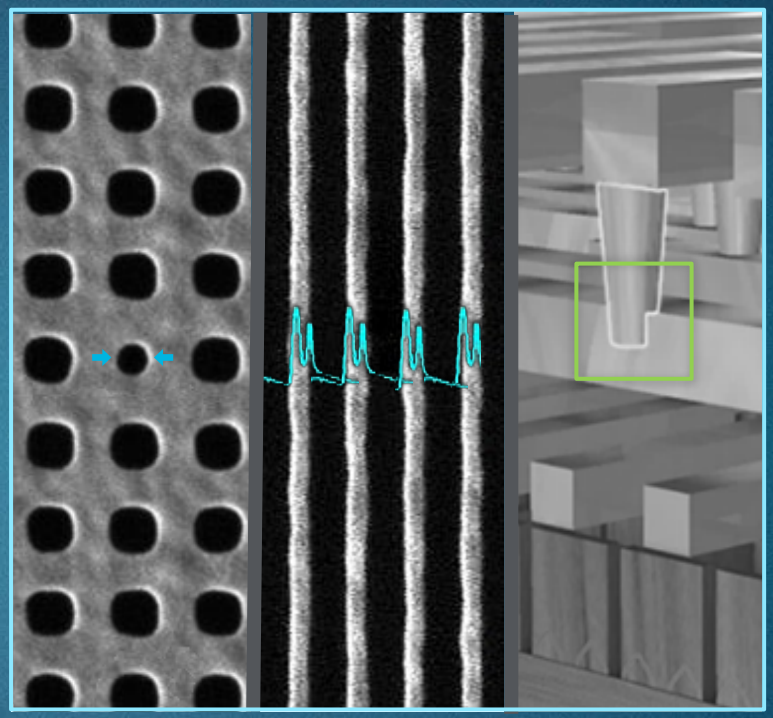
Defect Control and Patterning Control

Defect Control



Particle Bridge Scratch

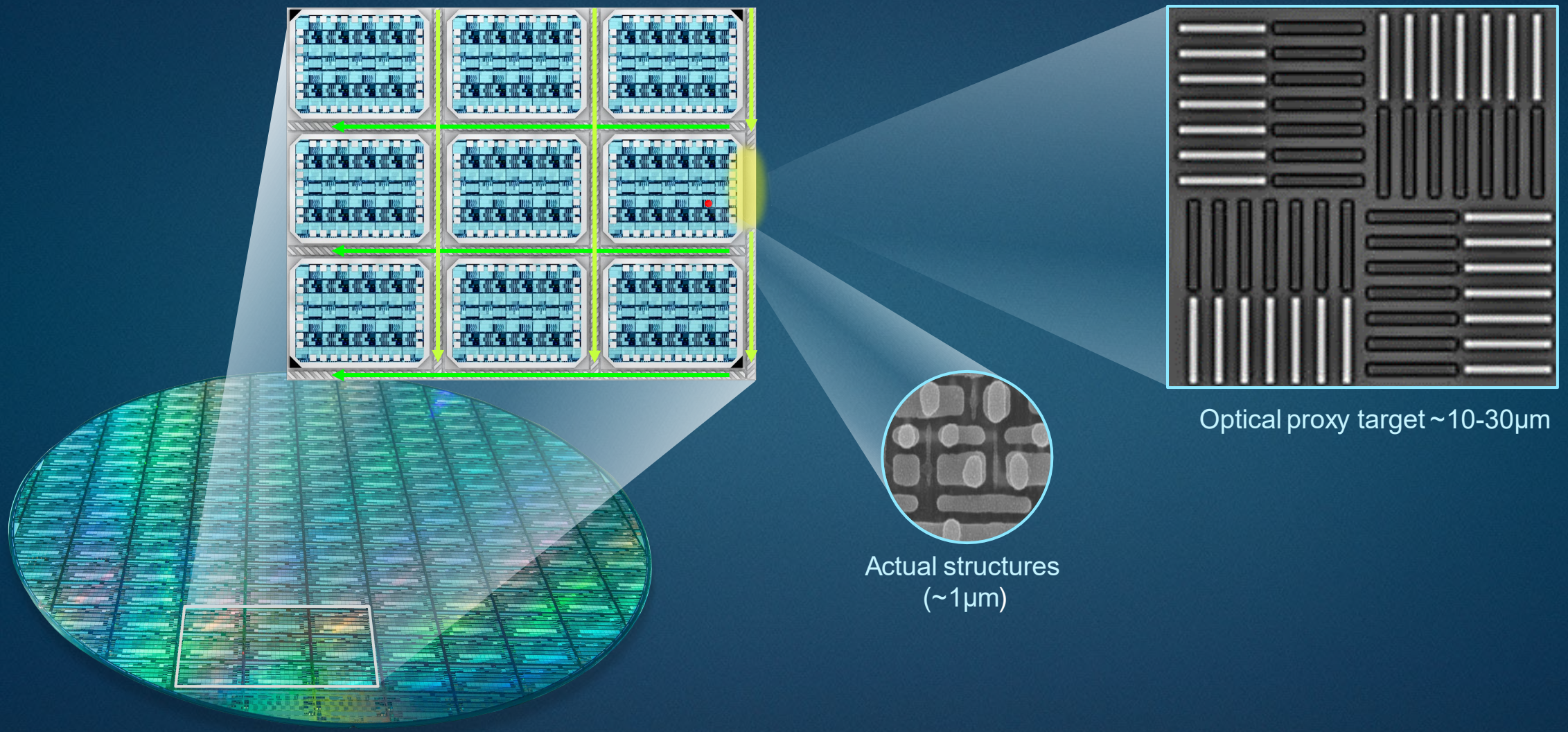
Patterning Control



Contact hole CD Line CD Overlay / placement error

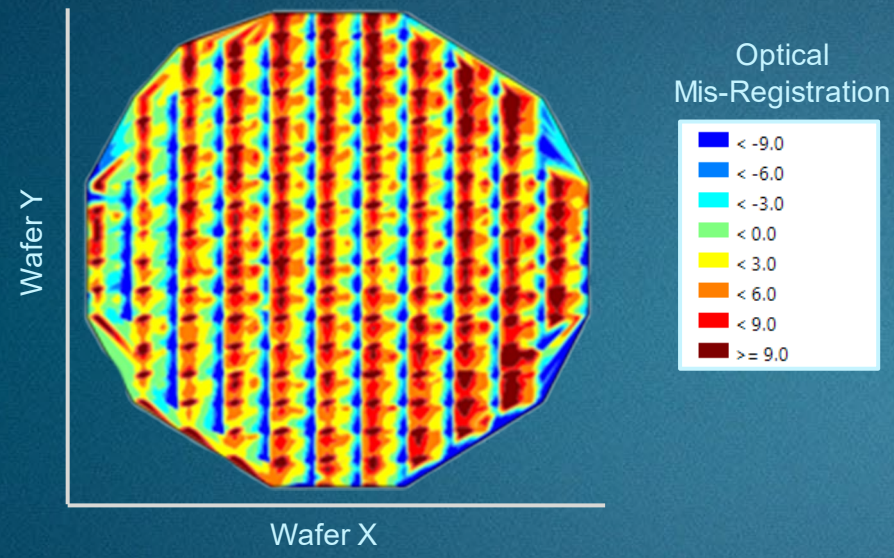
*CD = Critical Dimension

Traditional Patterning Control: Optical Approximation

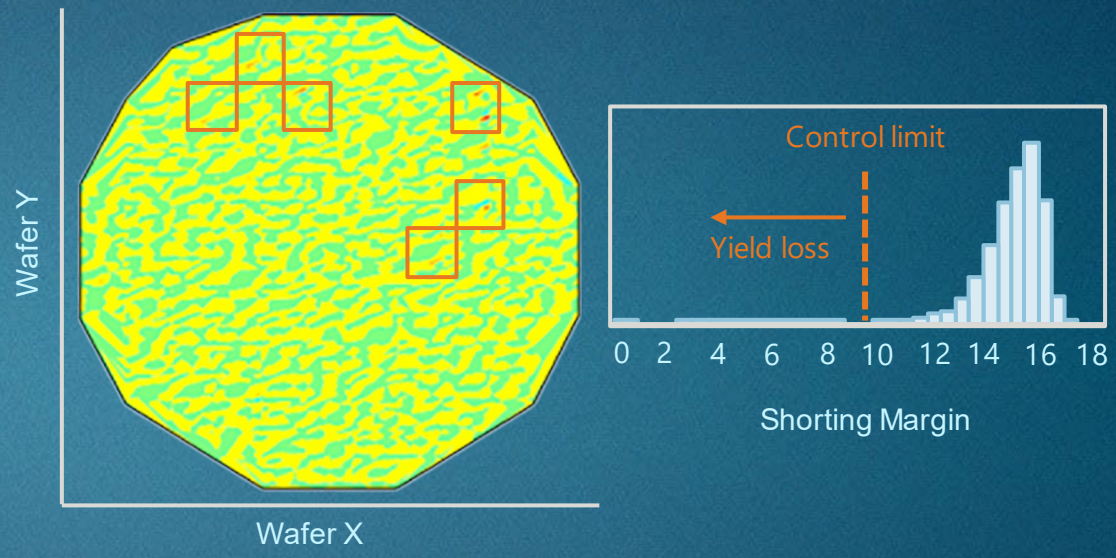


After-Development Inspection: ADI

Overlay Errors



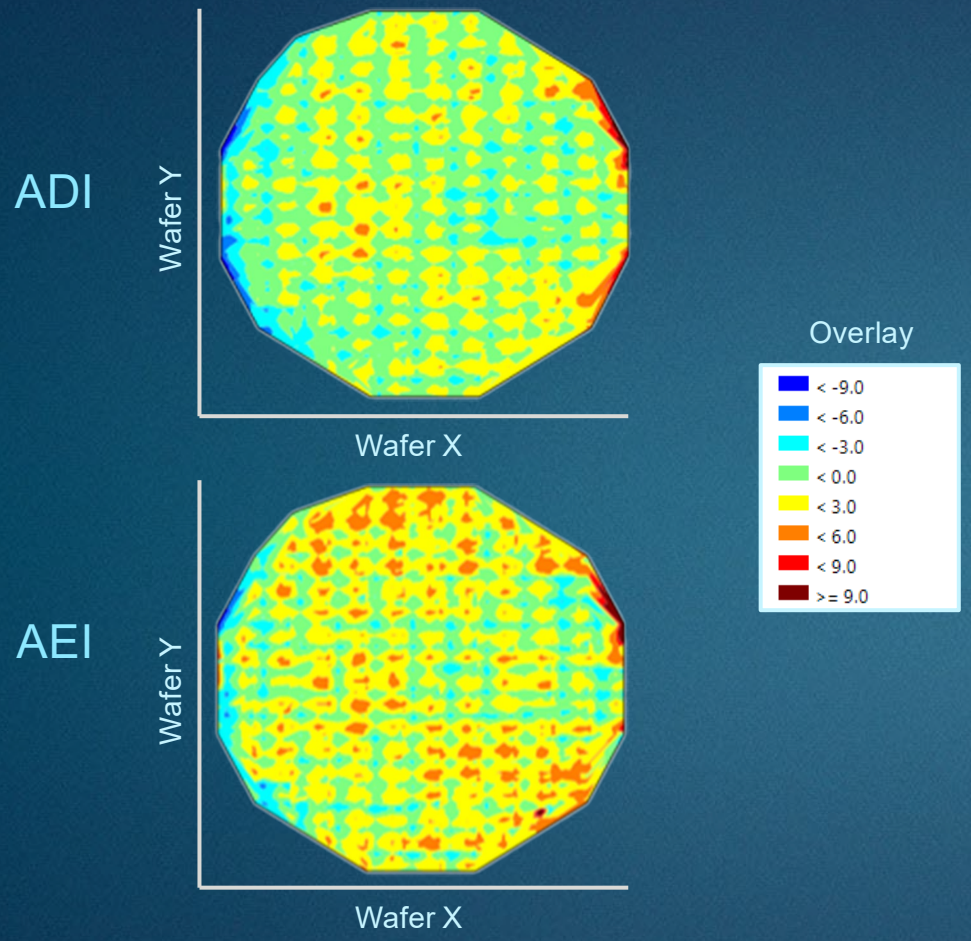
After Rework



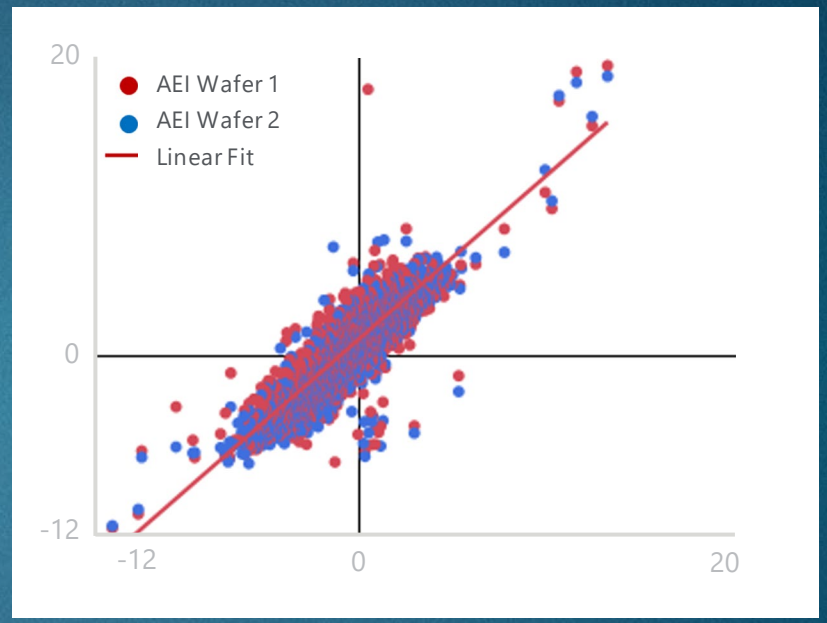
Source: Applied Materials

ADI = Critical decision of whether to etch or rework the pattern

After-Etch Inspection: AEI



ADI-to-AEI Correlation

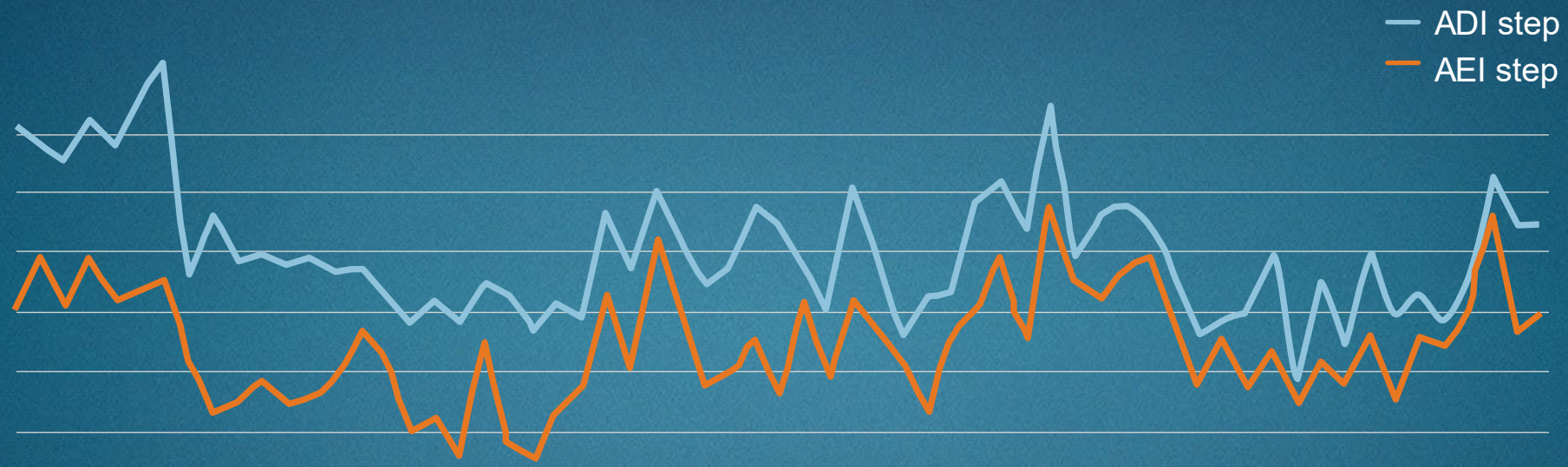


AEI = 1.03nm + 1.09 ADI

Source: Applied Materials

High correlation needed for effective patterning control

ADI vs. AEI Results Becoming Uncorrelated

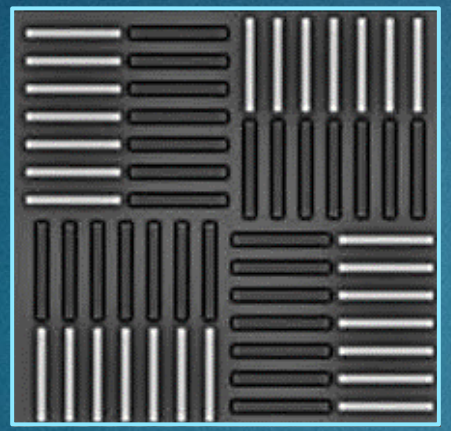


Source: Cornel Bozdog, Micron Technology, Inc. (United States) "Metrology requirements driven by memory scaling" (Keynote Presentation) Paper 11325-100, AEI mentioned as ACI in the source.

You can't fix what you can't measure.
You can't measure what you can't see.

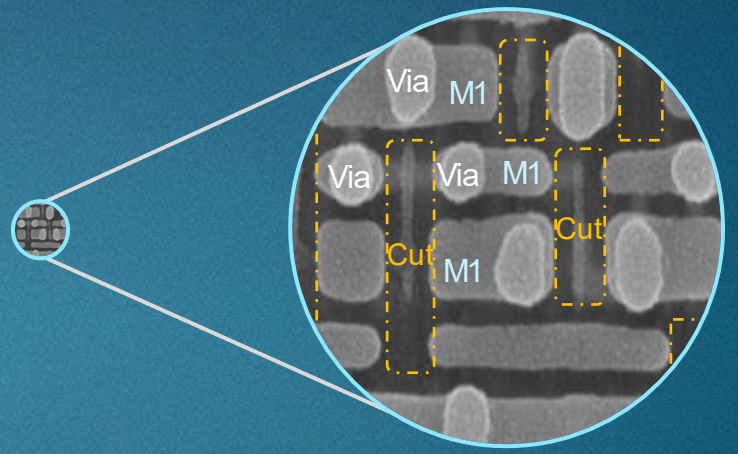
New Playbook: Element 1

OPTICAL



Target-based approximation

eBEAM

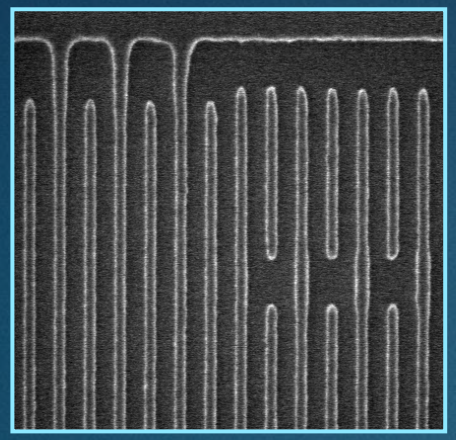


Actual on-device measurement

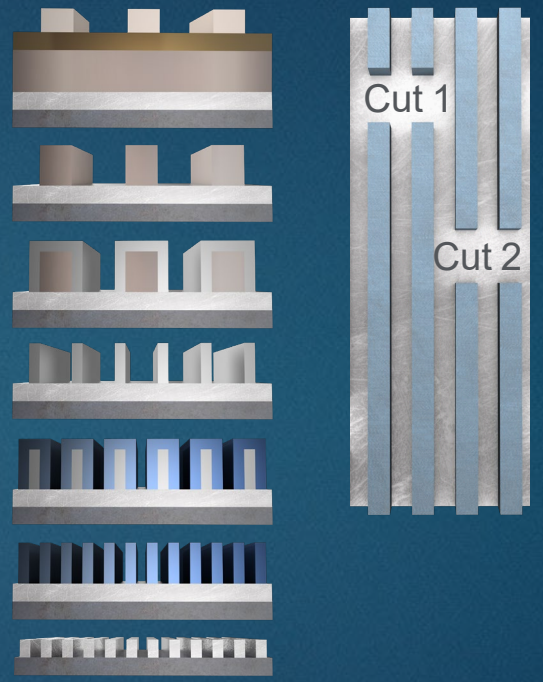
Element #1 - from target-based approximation to actual, on-device metrology

Single-Patterning has Become Multi-Patterning

SINGLE LITHO ETCH



MULTI-PATTERNING



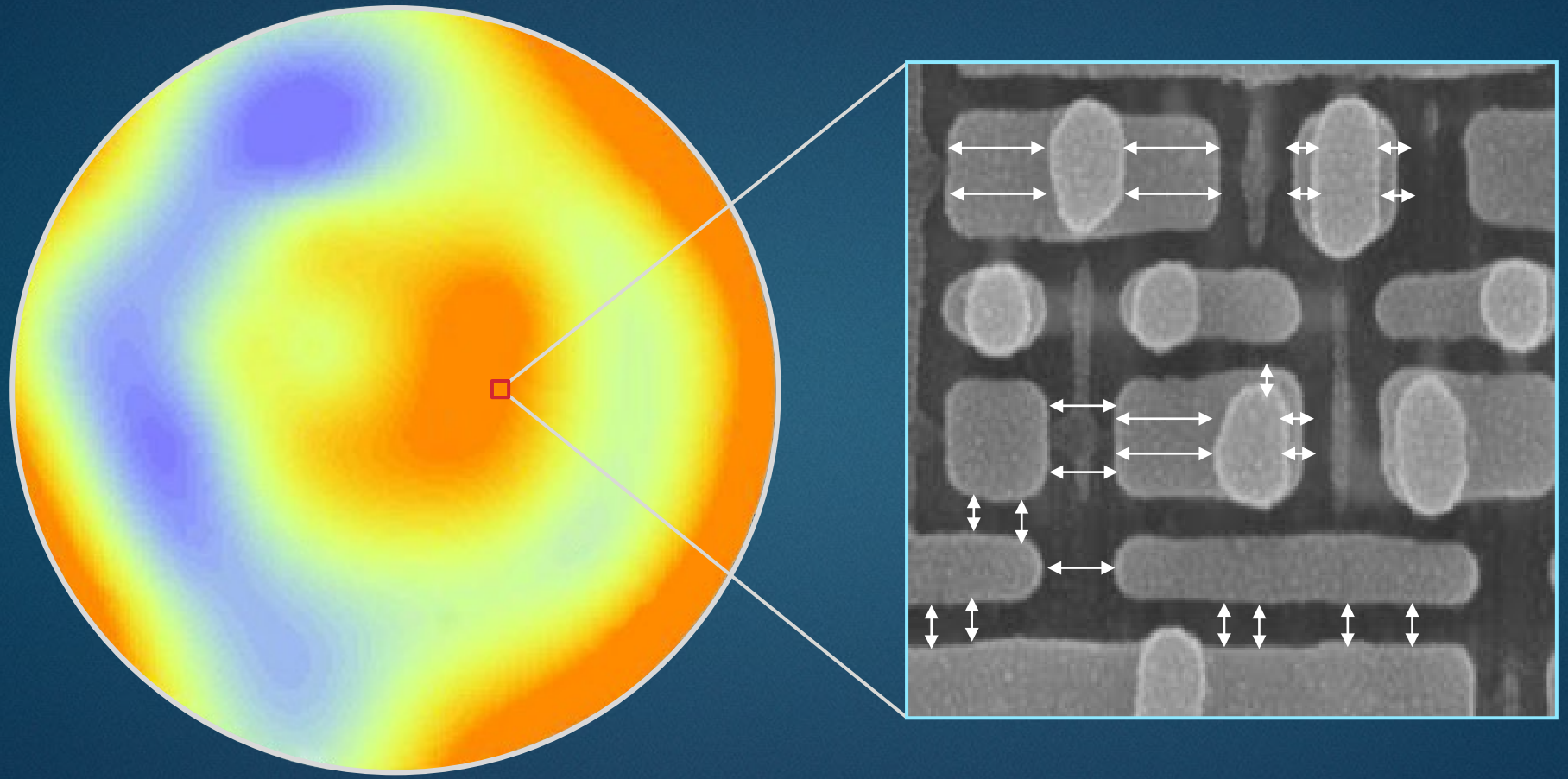
~450
STEPS

~1,200
STEPS

	Litho Etch	Litho x2 Etch x2	Litho x2 Etch x2	Litho x3 Etch x3 Film x3	Litho x4 Etch x4 Film x4
	28nm	20nm	14/16nm	10nm	7nm

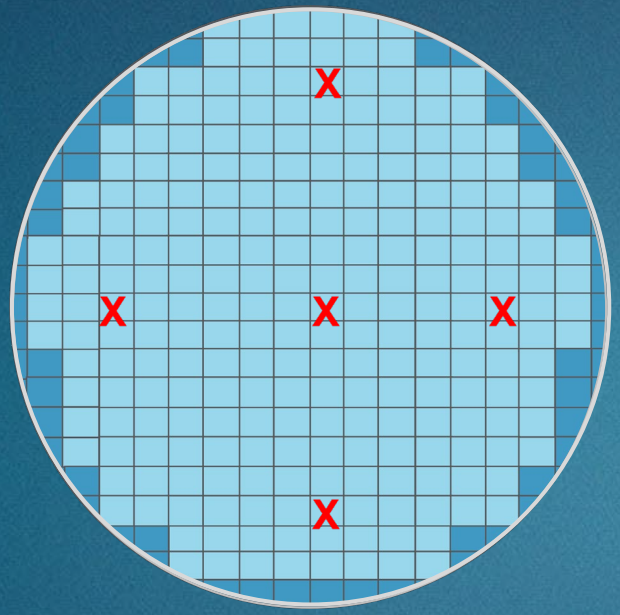
Source: Chipworks

Process Steps Introduce Variations Across the Wafer

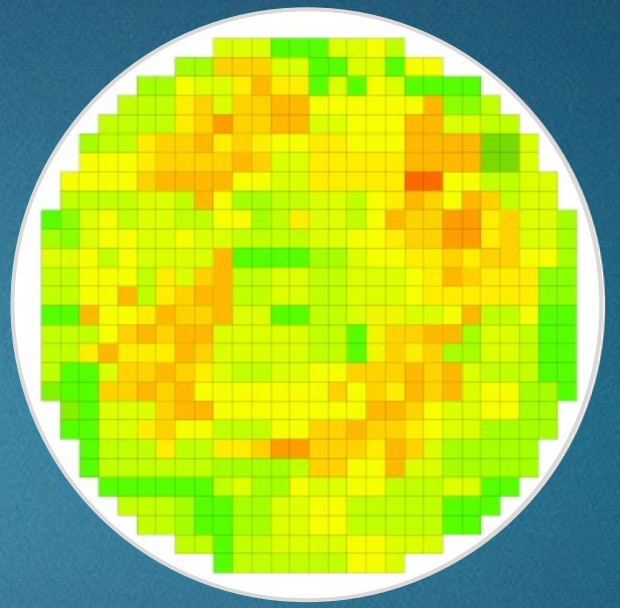


Source: Chipworks

New Playbook: Element 2



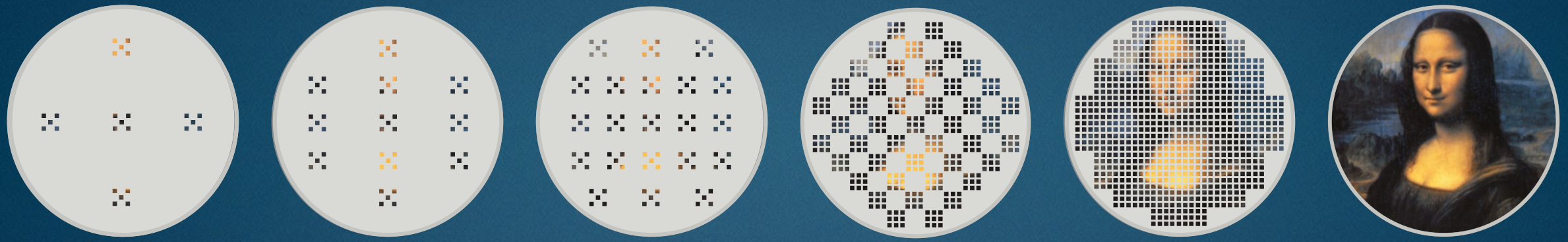
Statistical sampling



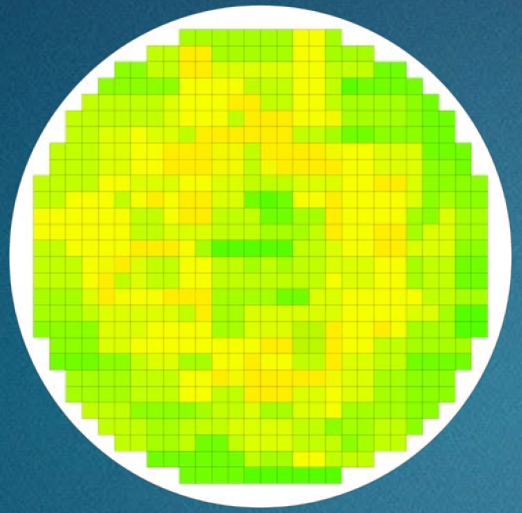
Massive measurements

Element #2 - from statistical sampling to massive, across-wafer sampling

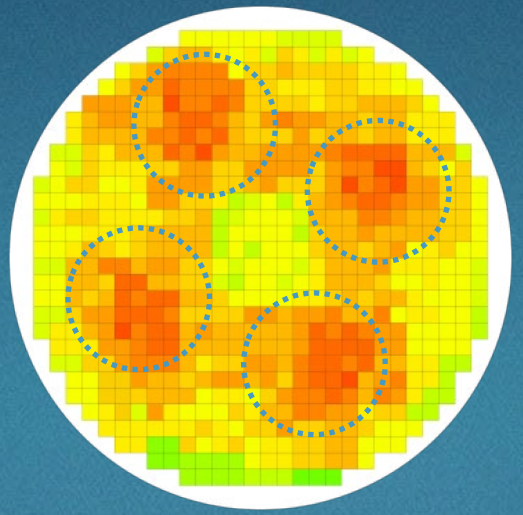
From Statistical Sampling to Massive Sampling



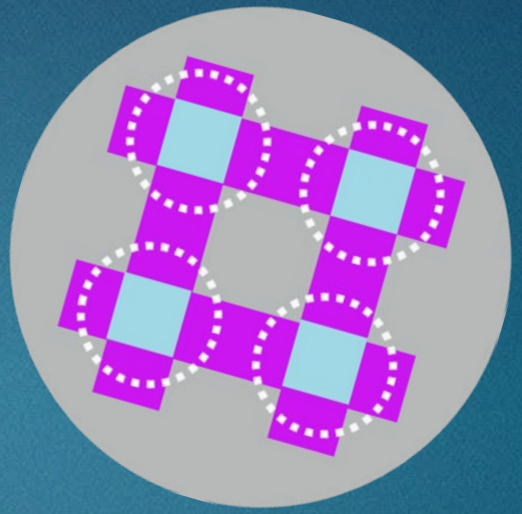
Massive Sampling Reveals Process-Induced Issues



Sparse sampling



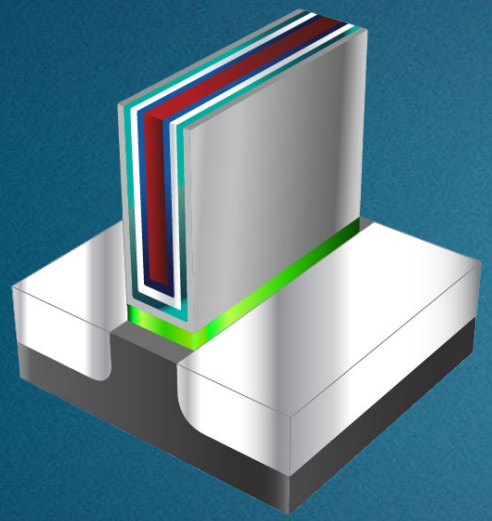
Massive sampling reveals process signature



UV cure chamber signature

An epiphany for process engineers

Planar to 3D Transition Requires More Measurements



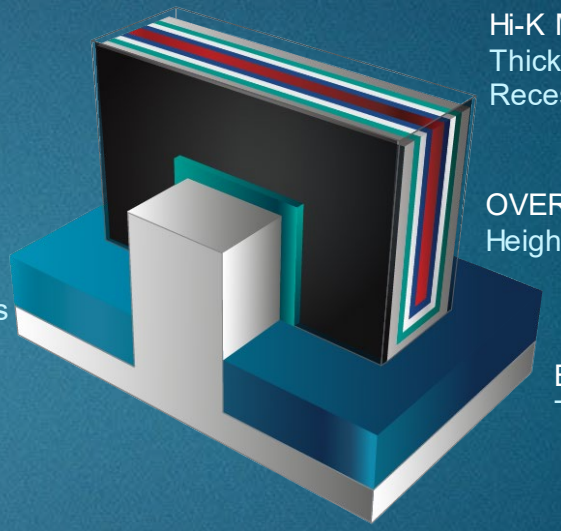
Thickness
Line width
Sidewall angle
CD

High-k Metal Gate

GATE
CD
Height
Sidewall angle

HARDMASK
Thickness
Width
Top corner radius

FIN
Height
Width
Sidewall angle



Hi-K METAL GATE
Thickness
Recess

OVERBURDEN
Height above Fin

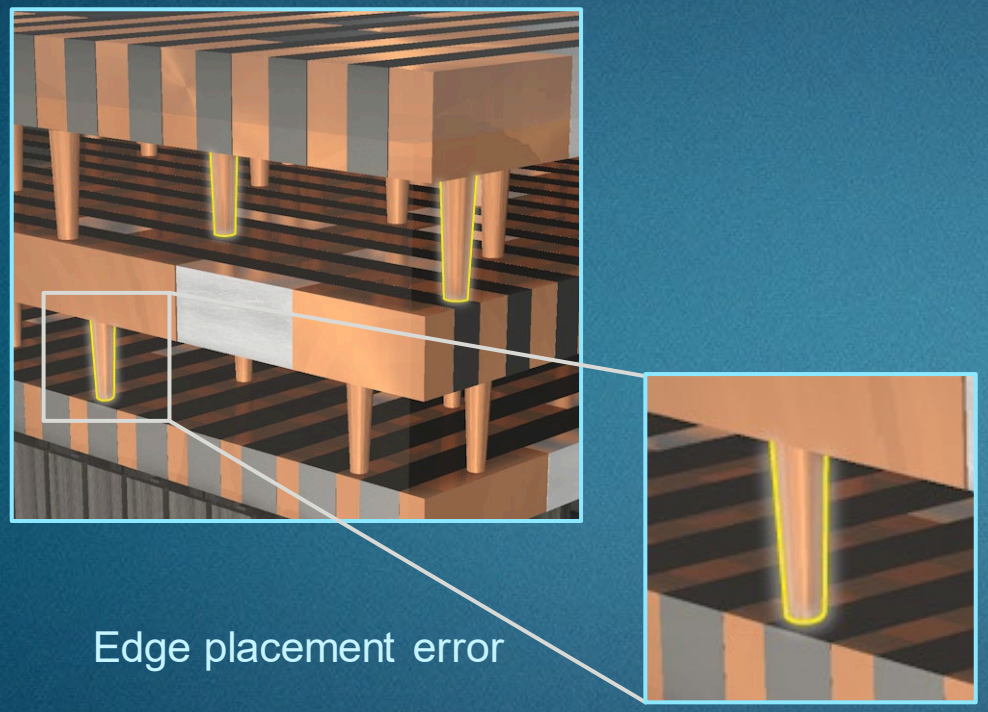
BOX
Thickness

3D FinFET

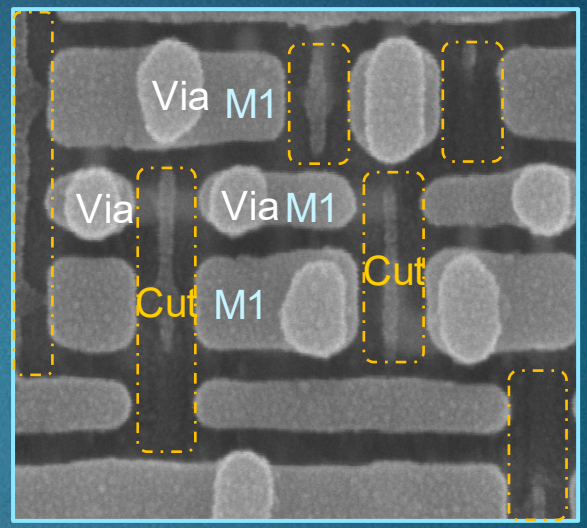
~3X greater number of measurements required

New Playbook: Element 3

3D structures create stresses and distortions that contribute to EPE



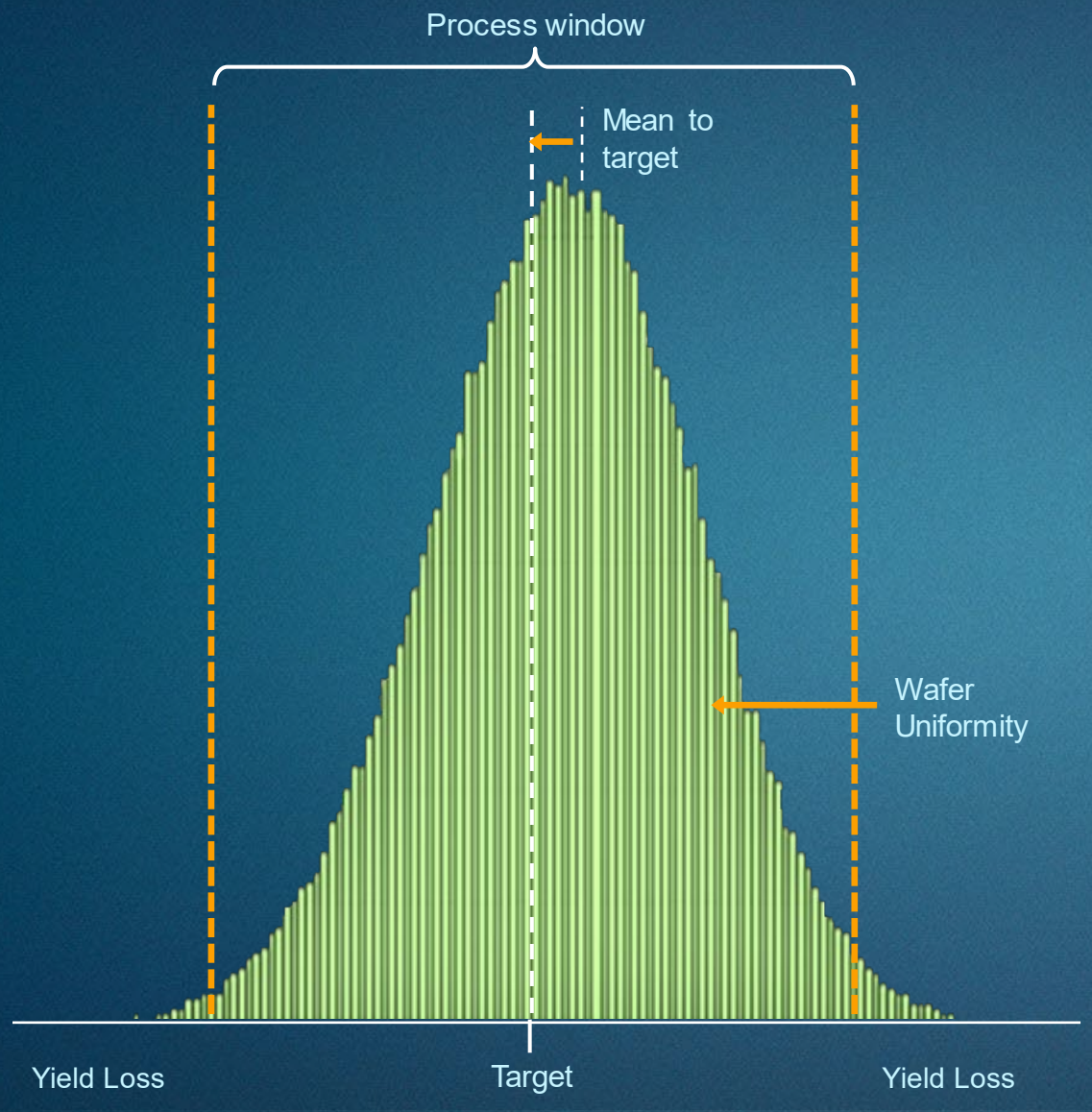
Edge placement error



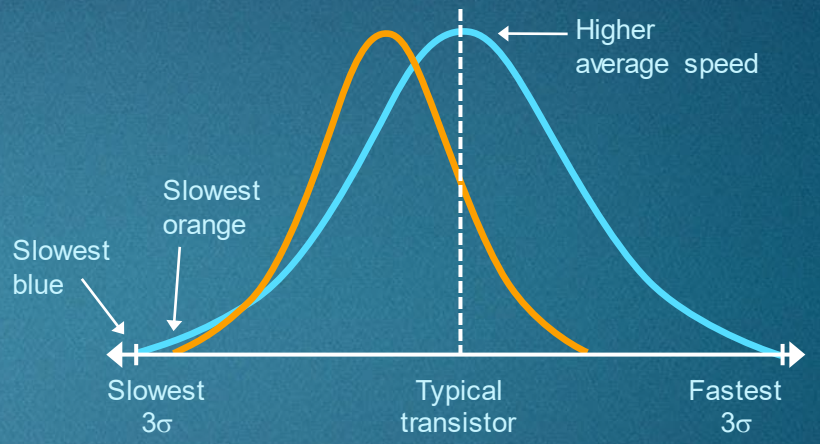
Multi-layer EPE metrology

Element #3 - from single-layer patterning control to 3D integrative control

Controlling Mean and Mean Variation



Variability implication

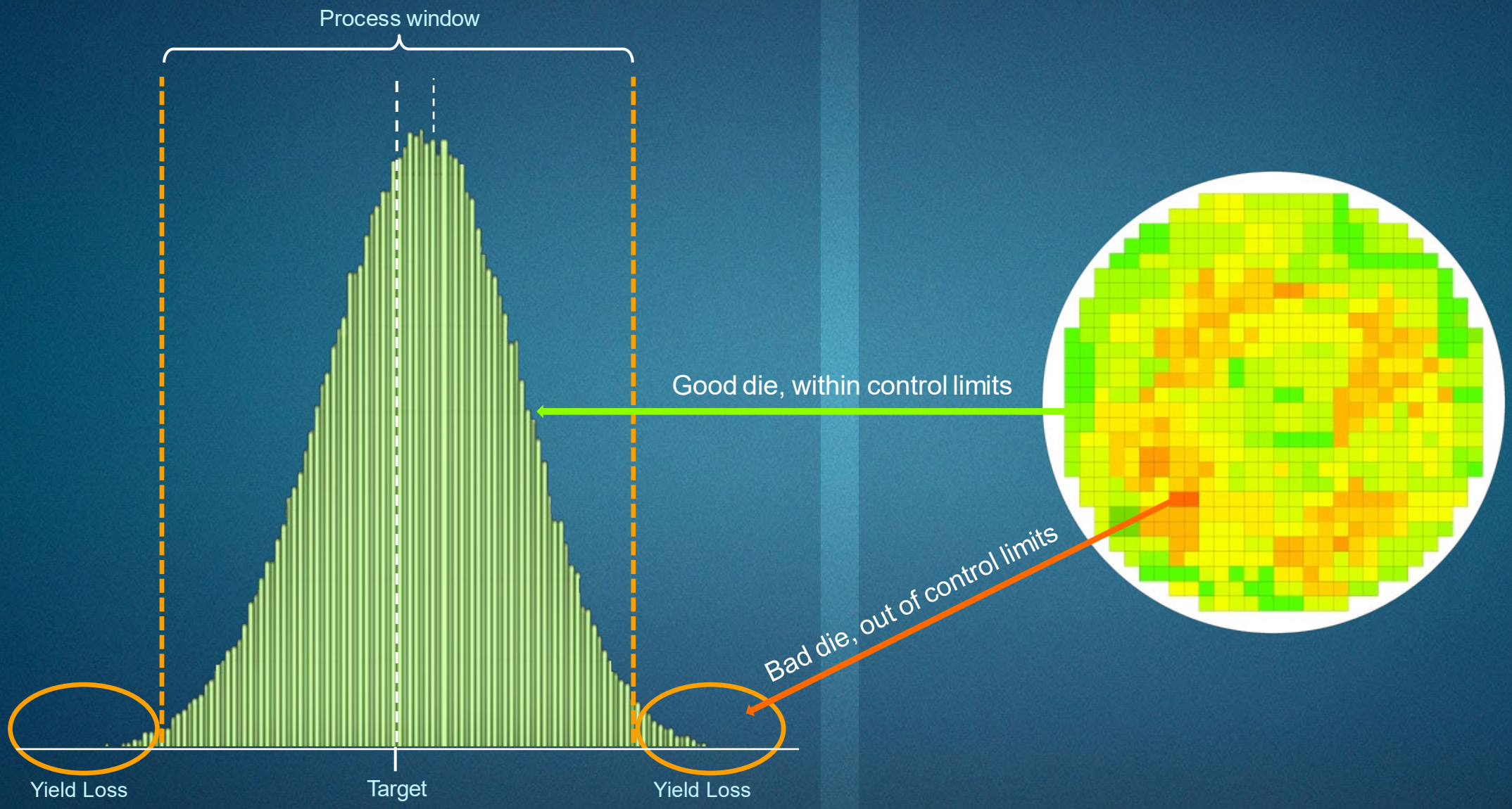


Greg Yeric, IEDM 2015

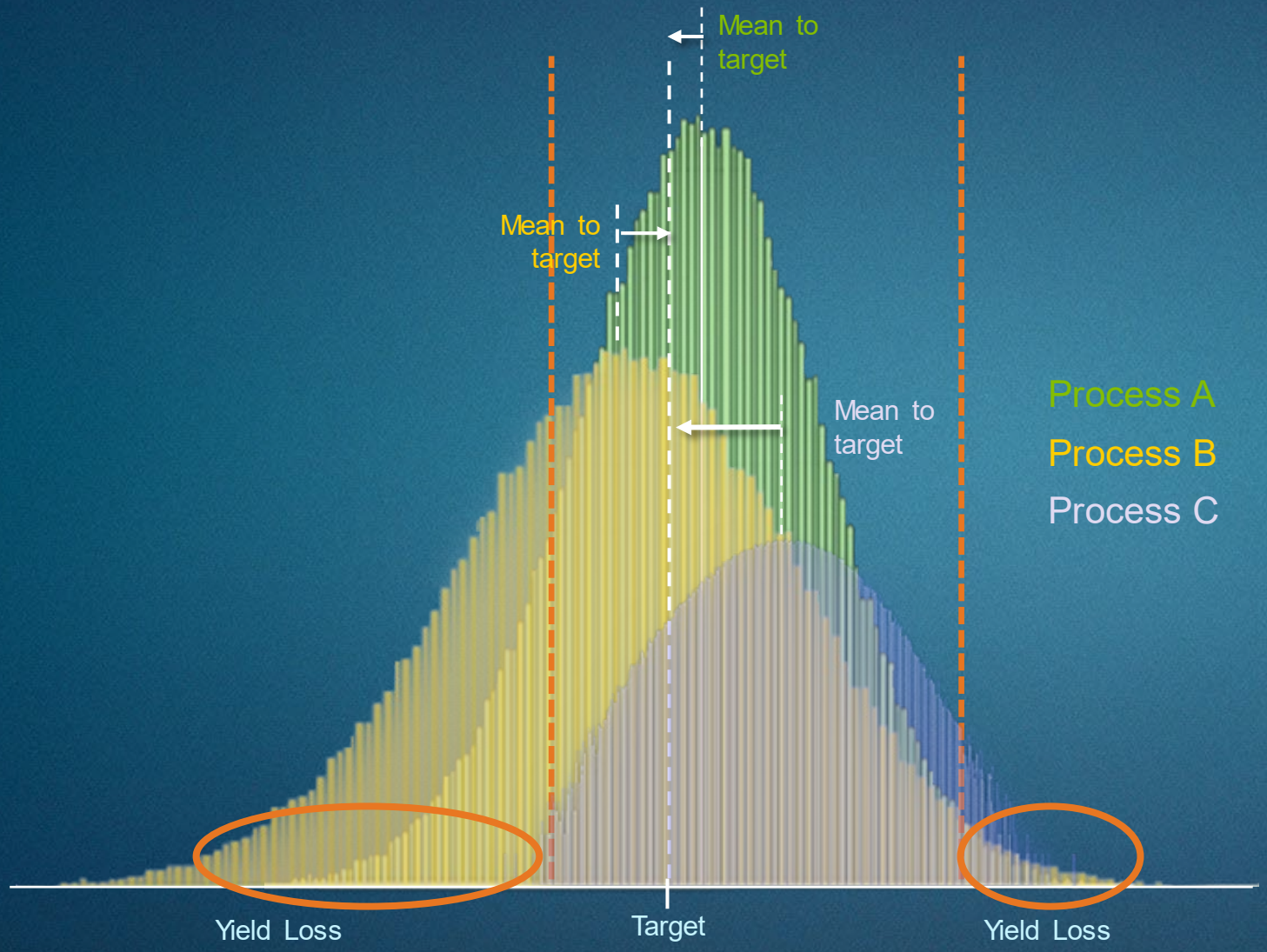
Circuit performance is gated by the slowest transistor

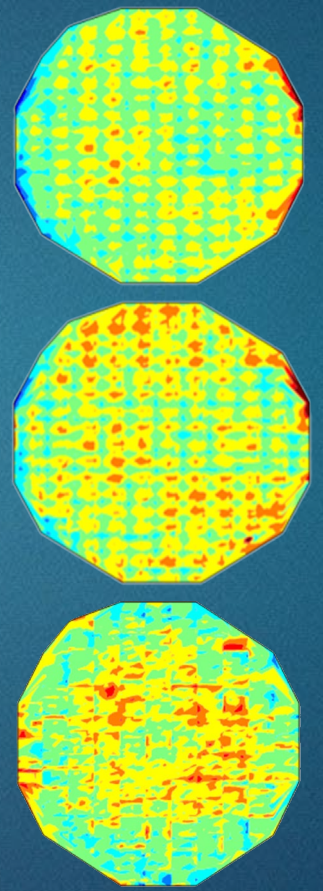
Lower transistor variability = higher device performance

Maintaining Process Window



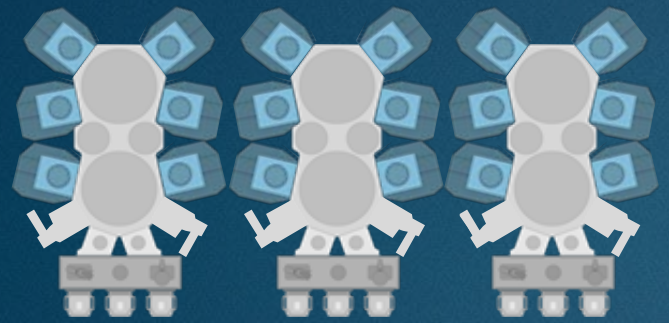
Goal: Widen the Combined Process Window





Applied AI^{x}: Actionable Insight Accelerator

Real-time ability to see into the process with innovative sensors, in-vacuum metrology



Process tools

>10,000 process possibilities per tool
>1,000,000 possibilities per integrated flow

+

Massive actionable data with unique metrology

PROVision®

+

AI^{x}™ analytics platform across all Applied tools

- ChamberAI™ ML algorithms
- AppliedPRO™
- Digital twin models
- Integrated controls

Making every stage faster and better: R&D, ramp and HVM
2X faster with 30% better process window

HVM = High Volume Manufacturing

Introducing PROVision® 3E eBeam Metrology System

1. **Resolution**
   Industry-leading eBeam column technology provides the highest electron density available, enabling detailed imaging at 1nm resolution.

2. **Accuracy**
   Leverages decades of CD SEM system and algorithm expertise to deliver accurate and precise measurements of critical features.

3. **Speed**
   10 million accurate, actionable measurements per hour.

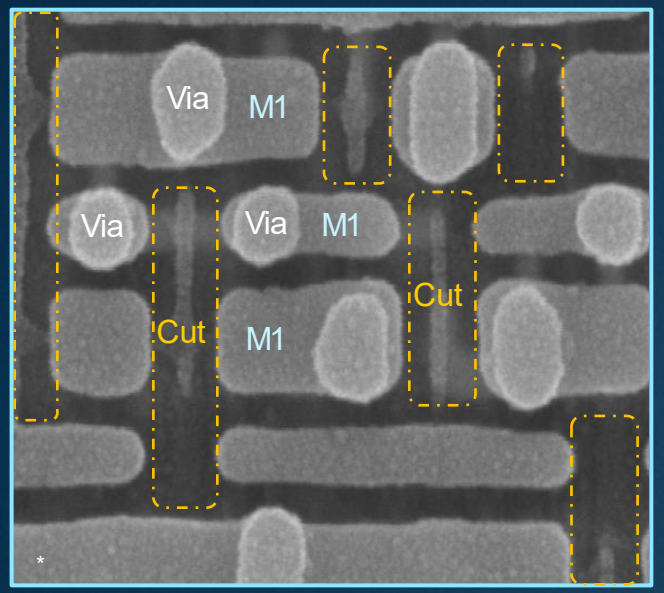
4. **Multi-Layer**
   Applied's unique Elluminator technology captures 95% of back-scattered electrons to quickly measure critical dimensions and edge placement at multiple levels simultaneously.

5. **Range**
   High-energy modes enable rapid measurement, hundreds of nanometers deep.
   Low-energy modes enable damage-free measurement of fragile materials and structures including EUV photoresist.

Over 30 systems installed at leading logic and memory customers

Introducing PROVision® 3E eBeam Metrology System

Edge Placement Error (EPE)



ERROR SOURCES

- Overlay/alignment
- CD uniformity of lines
- CD uniformity of cuts
- Line roughness
- Pitch walking

Simultaneous, multi-layer measurement of all the contributors to yield-limiting edge placement errors

$$\text{EPE error} = \sqrt{(\Delta\text{overlay})^2 + (\Delta\text{CDU}_{\text{lines}})^2 + (\Delta\text{CDU}_{\text{cuts}}) + (\Delta\text{LWR}_{\text{lines}})^2 + (\Delta\text{LWR}_{\text{cuts}})^2}$$

Patterning control of today's most advanced designs:
3D FinFET, gate-all-around, next-generation DRAM and 3D NAND

PROVision® 3E System

1. Resolution
2. Accuracy
3. Speed
4. Through-layer
5. Range

FROM	TO
Target approximation	On-device metrology
Statistical sampling	Massive across-wafer sampling
Single-layer control	3D integrative control

Massive metrology of

- Overlay accuracy
- CD uniformity
- Edge placement errors
- Line width roughness
- Process signatures

Enables a new playbook for patterning control

APPLIED MATERIALS®
make possible

Process Recipe Optimization

Lior Engel
Corporate Vice President, GM
Process Optimization and Control

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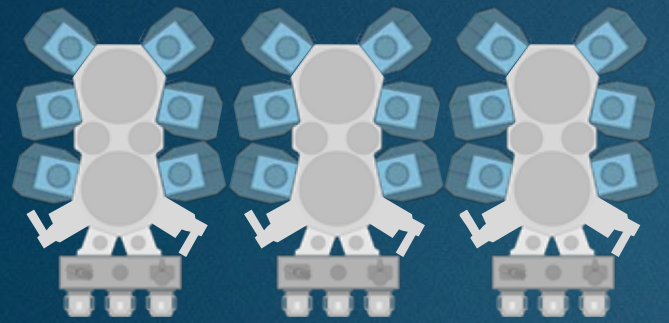
Real-time ability to see into the process with innovative sensors, in-vacuum metrology



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- Digital twin models
- Integrated controls

Making every stage faster and better: R&D, ramp and HVM
2X faster with 30% better process window

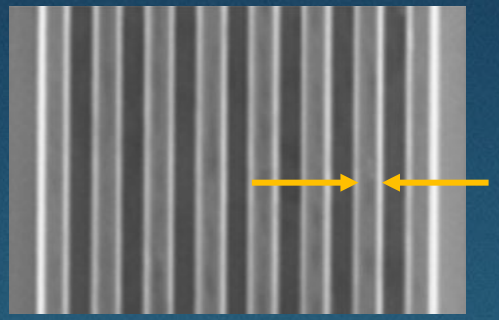
HVM = High Volume Manufacturing

Challenges of Enabling the “t” in PPACt™

28nm Process Optimization

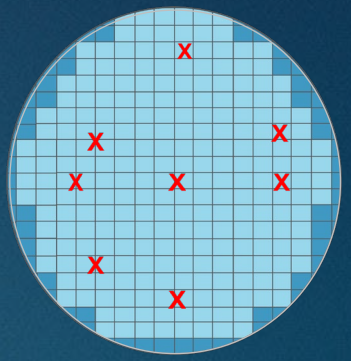
Etch control ~5 knobs

X



2D metrology

X

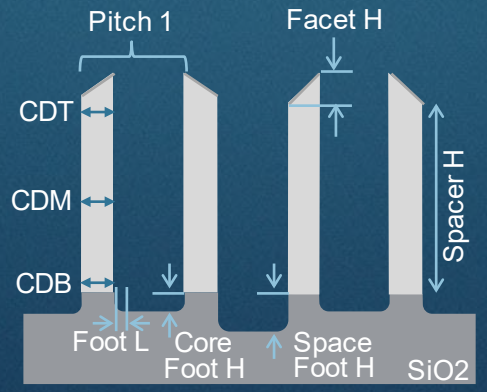


Statistical sampling

3nm Process Optimization

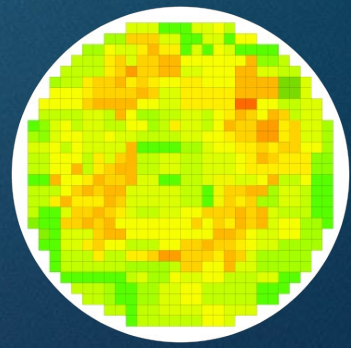
Etch control >20 knobs

X



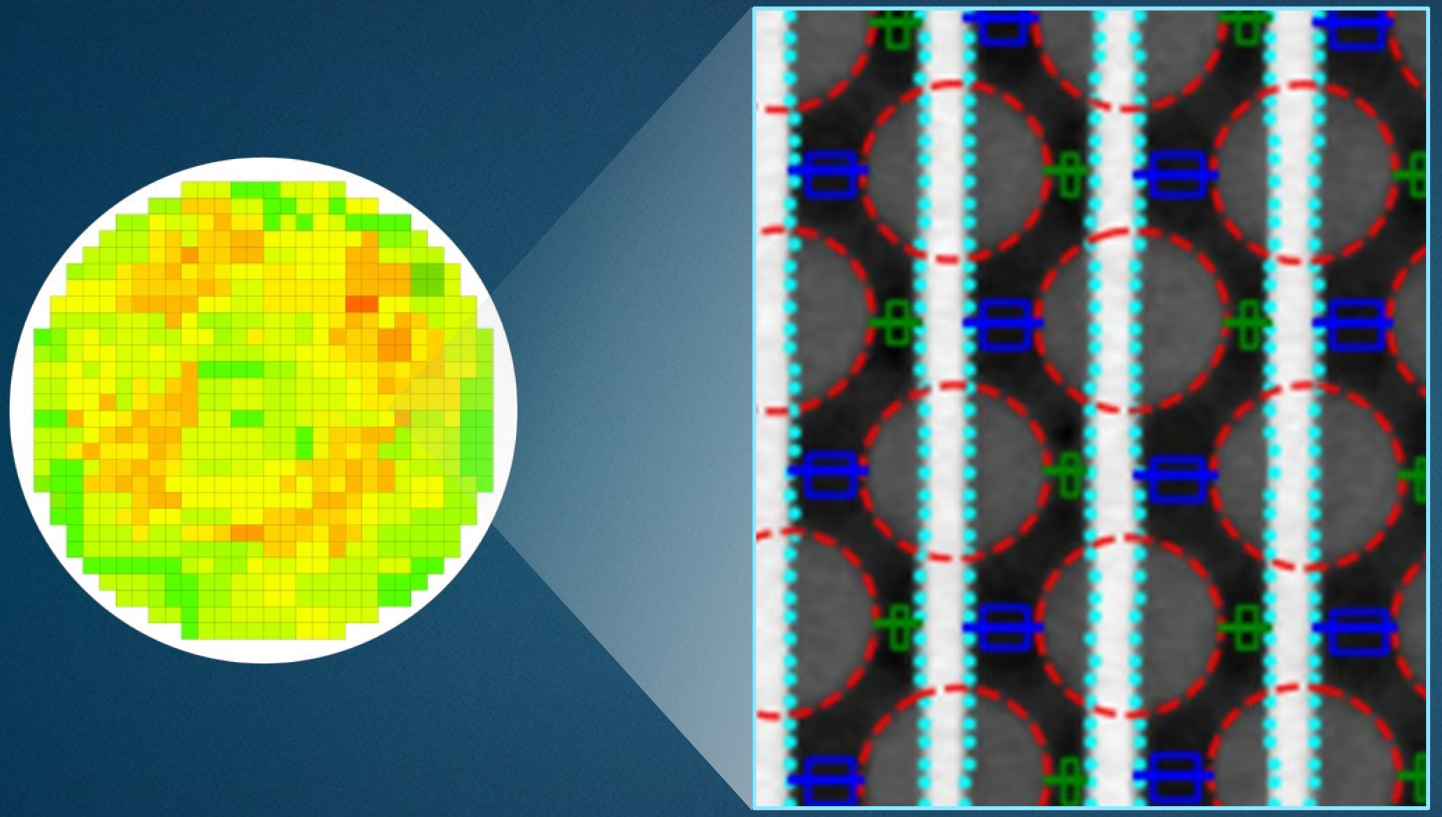
3D metrology

X



Massive measurements

PROVision Based Co-Optimized Metrology



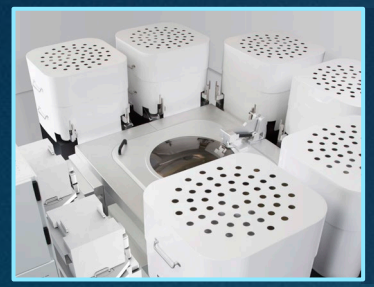
Process developers collaborating with eBeam developers to create co-optimized solutions

Transferring optimized process and metrology recipes from SCLA labs to customer R&D

Developing co-optimized materials engineering and metrology solutions

AppliedPRO: Applied Process Recipe Optimizer

Process parameters



Centris® Sym3®

RF
Chemistry
Pressure
Temperature
Bias
Time

AppliedPRO

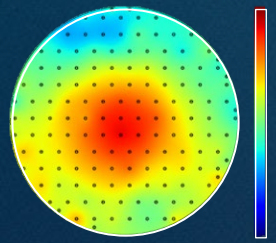
On-wafer metrics

CD
Defectivity
Tilt
Composition
Stress
Ellipticity

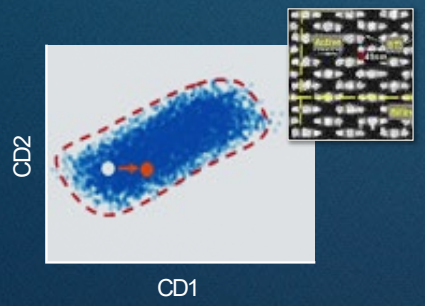
PROVision +
any metrology tool

Benefits of integrated solution

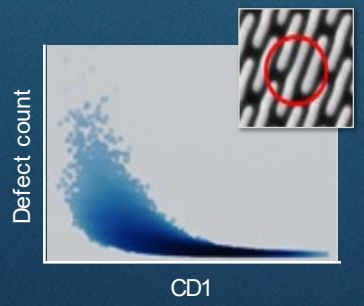
Spatial signature



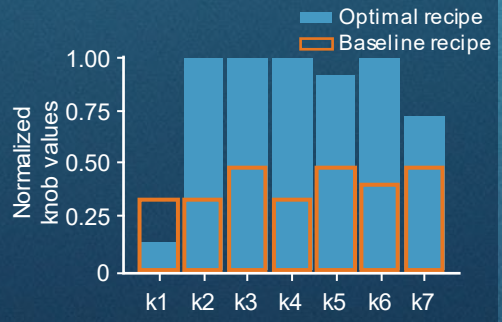
Process trade-offs



Defect windows



Recipe predictions



Benefits of AppliedPRO with PROVision metrology

CD uniformity reduces power consumption

Conventional

AppliedPRO ← 40%

Process optimization time (days)

Conventional

AppliedPRO ← 5X

Wafer reduction – positive ESG impact

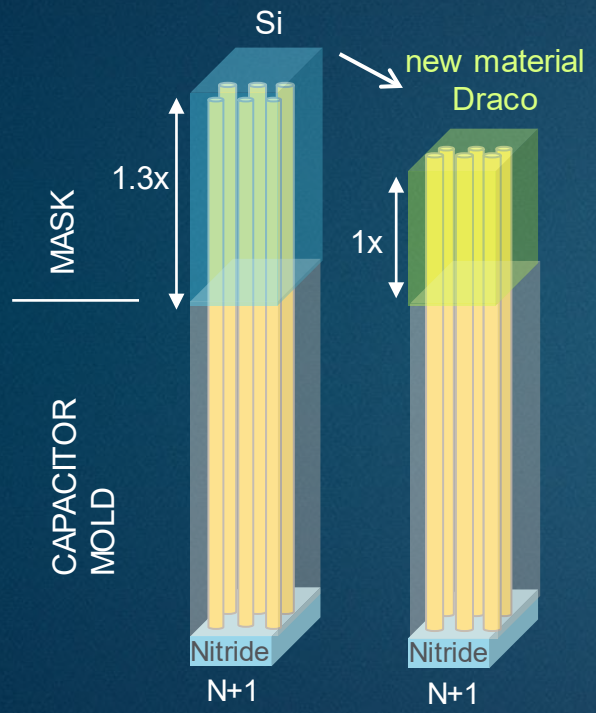
Conventional

AppliedPRO ← 3X

APPLIED MATERIALS

Innovations to Enable Low-Variability, High-AR* Etch Process

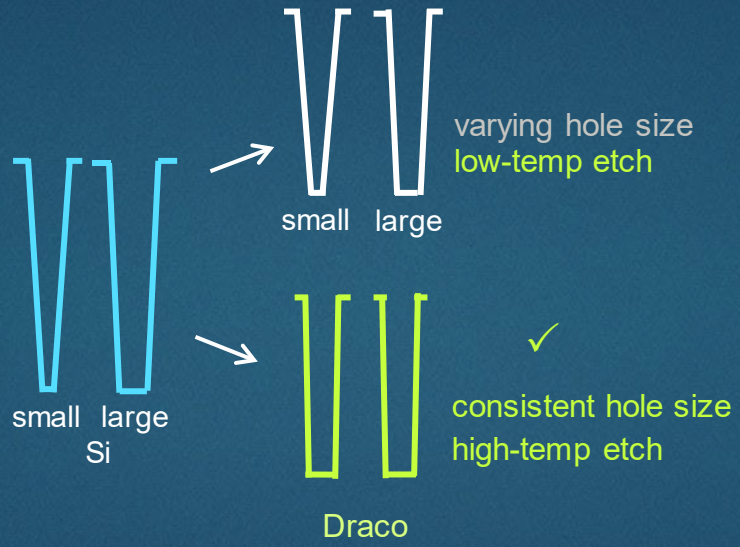
Draco™: New hard mask material
(Higher modulus and selectivity)



Tunable film properties for selectivity
Unique precursor chemistry

+

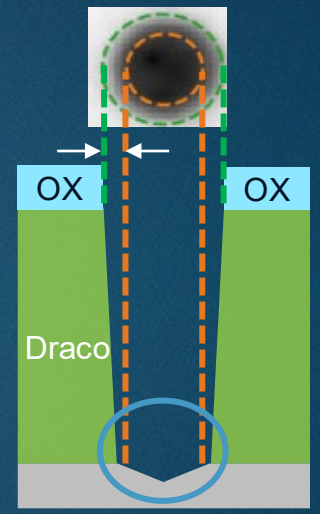
New high-temp etch technology
(Better profile and CD uniformity)



Industry leading >200C capability
Higher conductance Sym3® design

+

Unique metrology
(Faster and better sampling error)



Non-destructive bottom imaging with actionable measurements

* CD = Critical Dimension
* AR = Aspect Ratio

Process and Metrology Co-Optimization Enabling “t” in PPACt

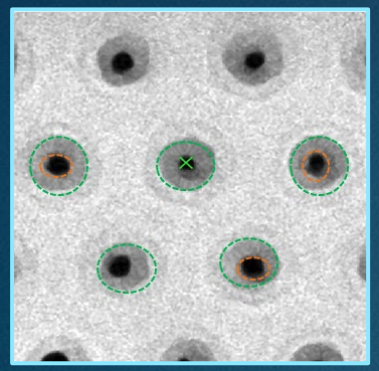
>20 etch process control knobs

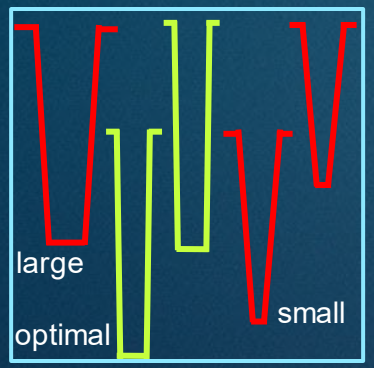
+

AppliedPRO with PROVision metrology

=

Co-optimized etch and metrology solution

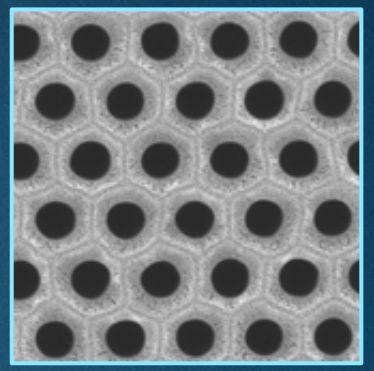


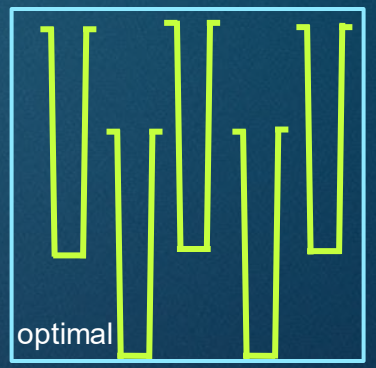


PROVision

+

AppliedPRO





Latest POC win: New CVD hardmask film co-optimized with Sym3® Y etch for 3D NAND memory hole patterning

Imaging and Process Control Business Opportunities

Keith Wells
Group Vice President, GM
Imaging and Process Control Group

PROCESS CONTROL and AppliedPRO™ MASTER CLASS | October 18, 2021

KEY Messages

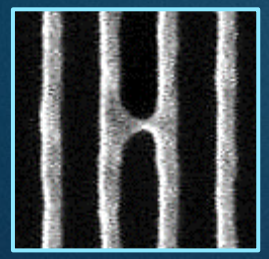
1. Applied's Imaging and Process Control Group (IPC) includes Process Optimization and Control (POC) and Process Diagnostics and Control (PDC)

2. Strategy: POC uses eBeam and AI to accelerate process R&D and improve PPACt™ at Applied and for our customers; PDC uses optical, eBeam and AI to deliver cutting-edge inspection and metrology solutions for PPACt

3. IPC Objective: Outperform the PDC market and drive profitable growth for Applied Materials

Applied's eBeam Portfolio

SEMVision®
Defect Review

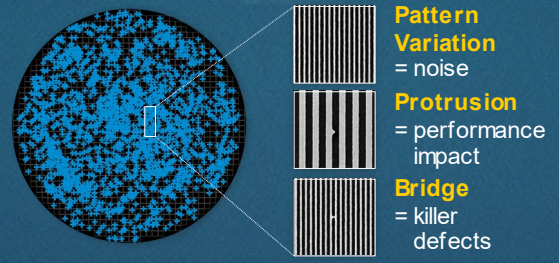


Defect classification

Applying Big Data + AI Strategy

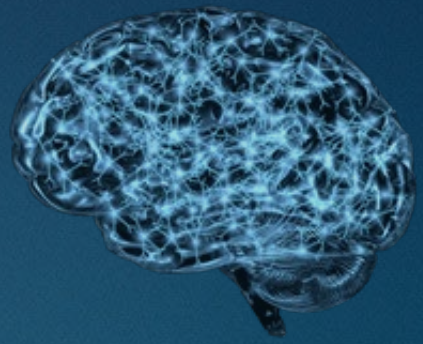
1. Unclassified Data

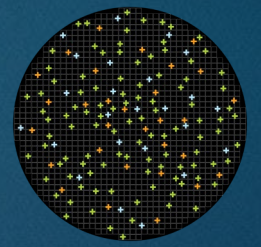
Use Enlight system to quickly generate database of potential defects



2. Classification & Training

Use SEMVision system to train ExtractAI™ to classify defects and noise



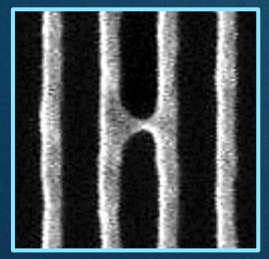


3. Inferencing

Enlight with ExtractAI now automatically recognizes specific defects across the wafer map

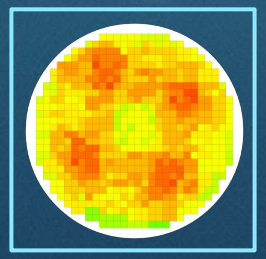
Applied's eBeam Portfolio

SEMVision®
Defect Review



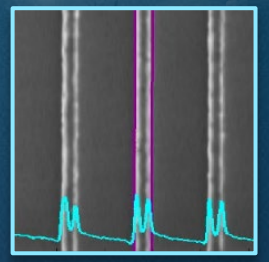
Defect classification

PROVision® eBeam
Emerging SEM Metrology



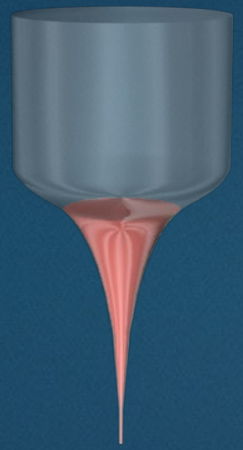
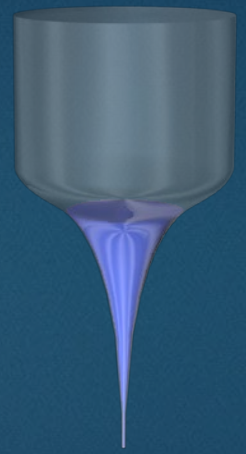
Massive sampling

VeritySEM® eBeam
CD Metrology



CD metrology

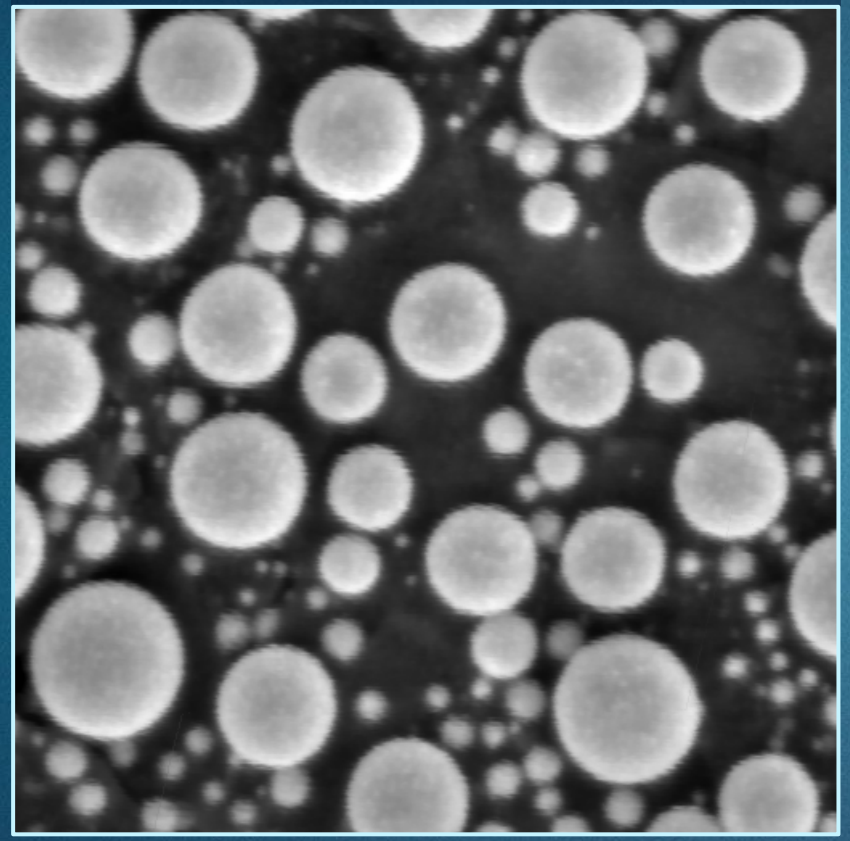
eBeam Imaging Sources Over Time

~1970 Thermal Source	~1990 Thermal Field Emission Source	~2020* Cold Field Emission Source	
			Applied's CFE technology increases resolution and speed – no compromise
2700	1800	300	Operating Temperature (°K)
>5	1-5	<1	Resolution (nm)
1x	3-6x	9-100x	Imaging Speed

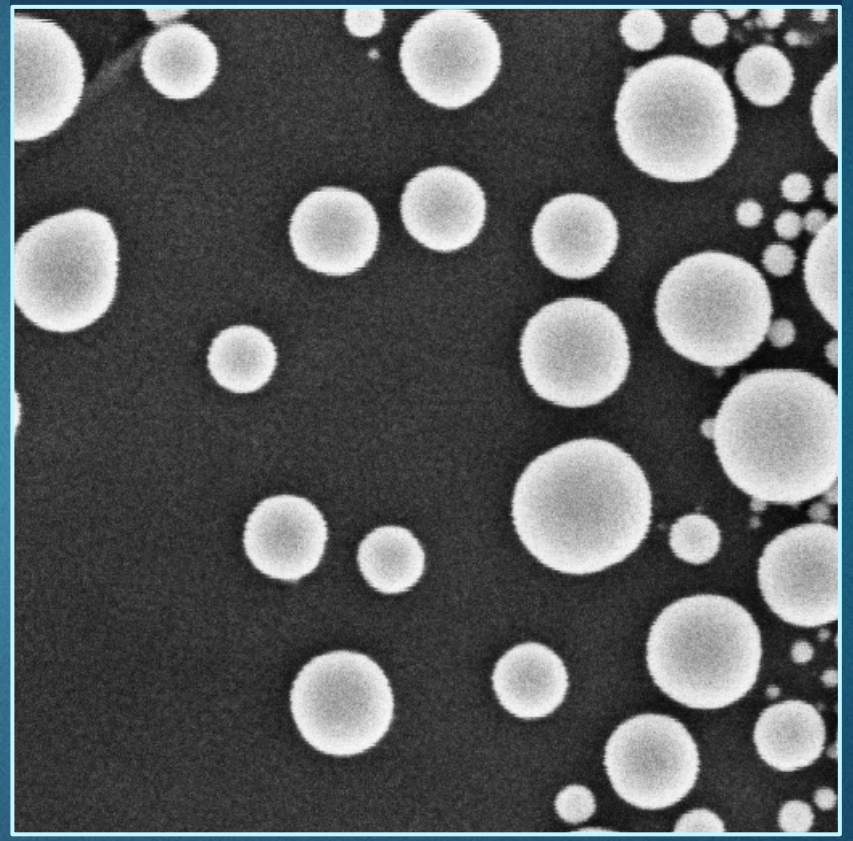
*Production worthiness achieved in 2021

The Next Generation of eBeam Imaging

Thermal Field Emission Source



Cold Field Emission Source



Higher resolution, faster throughput, production worthy

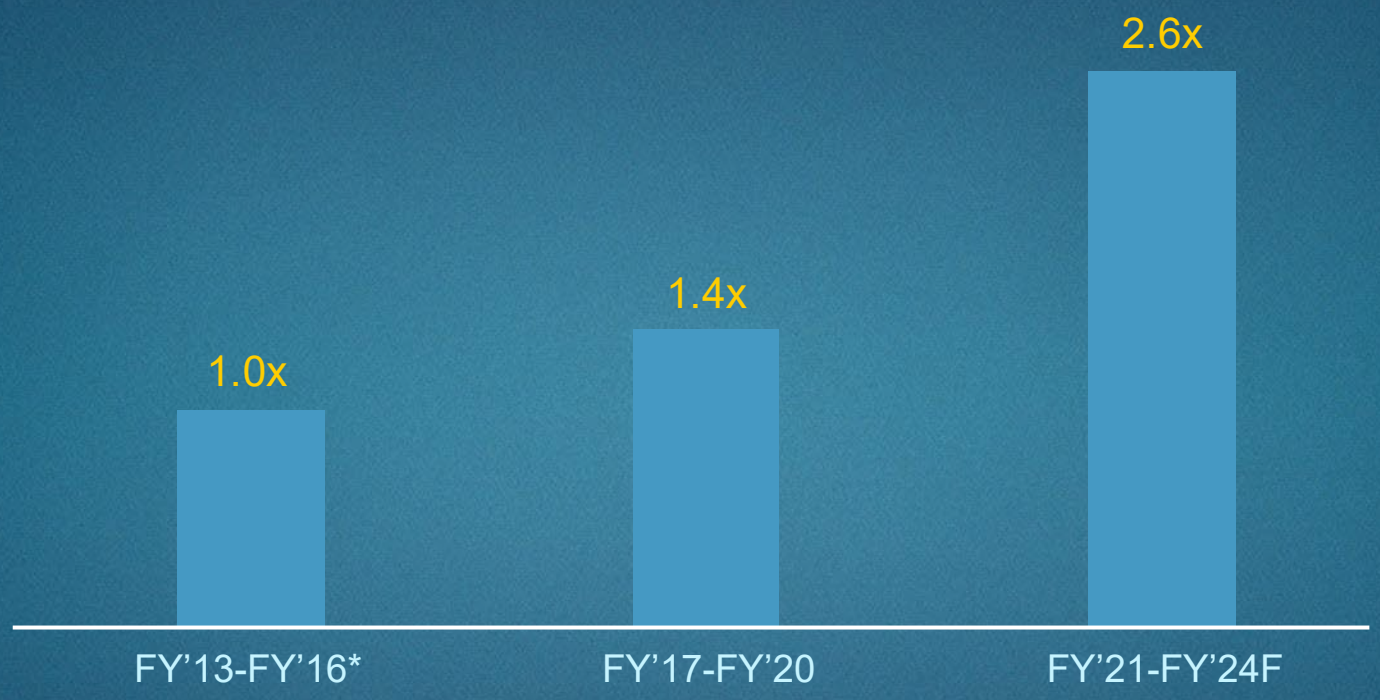
Applied's Process Control Served Markets

Category	Market Segment*	2020 TAM ($M)	Applied 2020 Rev ($M)	Applied Product
Metrology	CD Metrology/CD Measuring CD Measuring Tools	$617	$123	VeritySEM
Emerging SEM Metrology				PROVision
Inspection	Patterned Wafer Inspection eBeam	$439	$139	PROVision
	Defect Review Stations	$376	$293	SEMVision
	Patterned Wafer Inspection Darkfield	$743	$271	Enlight
	Patterned Wafer Inspection Brightfield	$1,146		
Mask	Reticle Inspection and Metrology Systems	$862	$49	Aera
			$876	

Enlight® is BF and DF

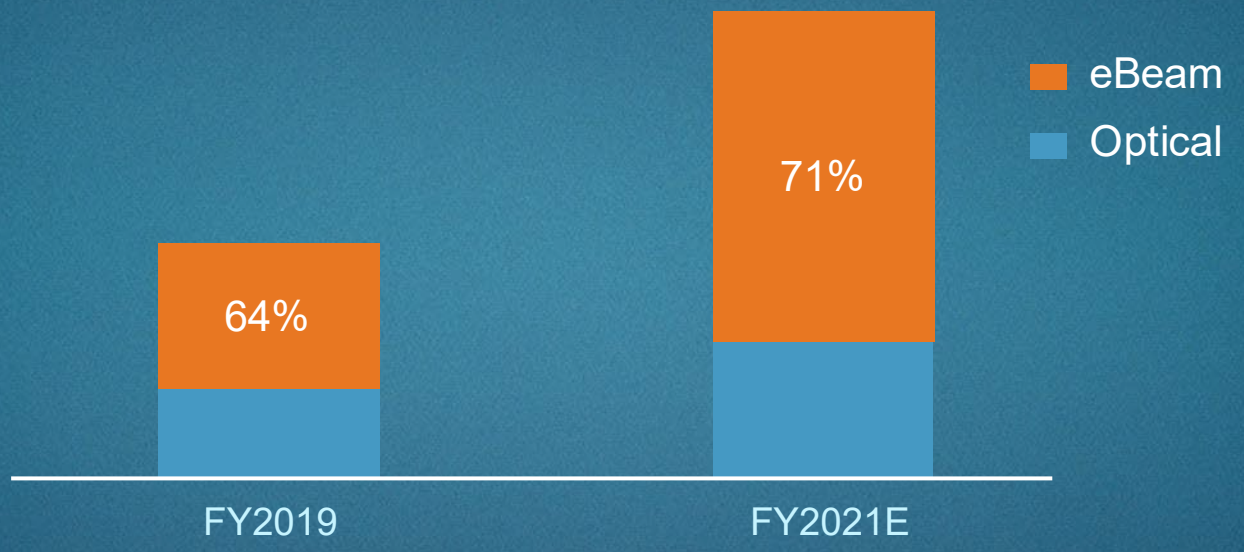
Source: *VLSI Research, Applied Materials. Majority of revenue reported in semiconductor systems. Legacy process control equipment reported in AGS.

IPC Group Revenue Growth Outlook

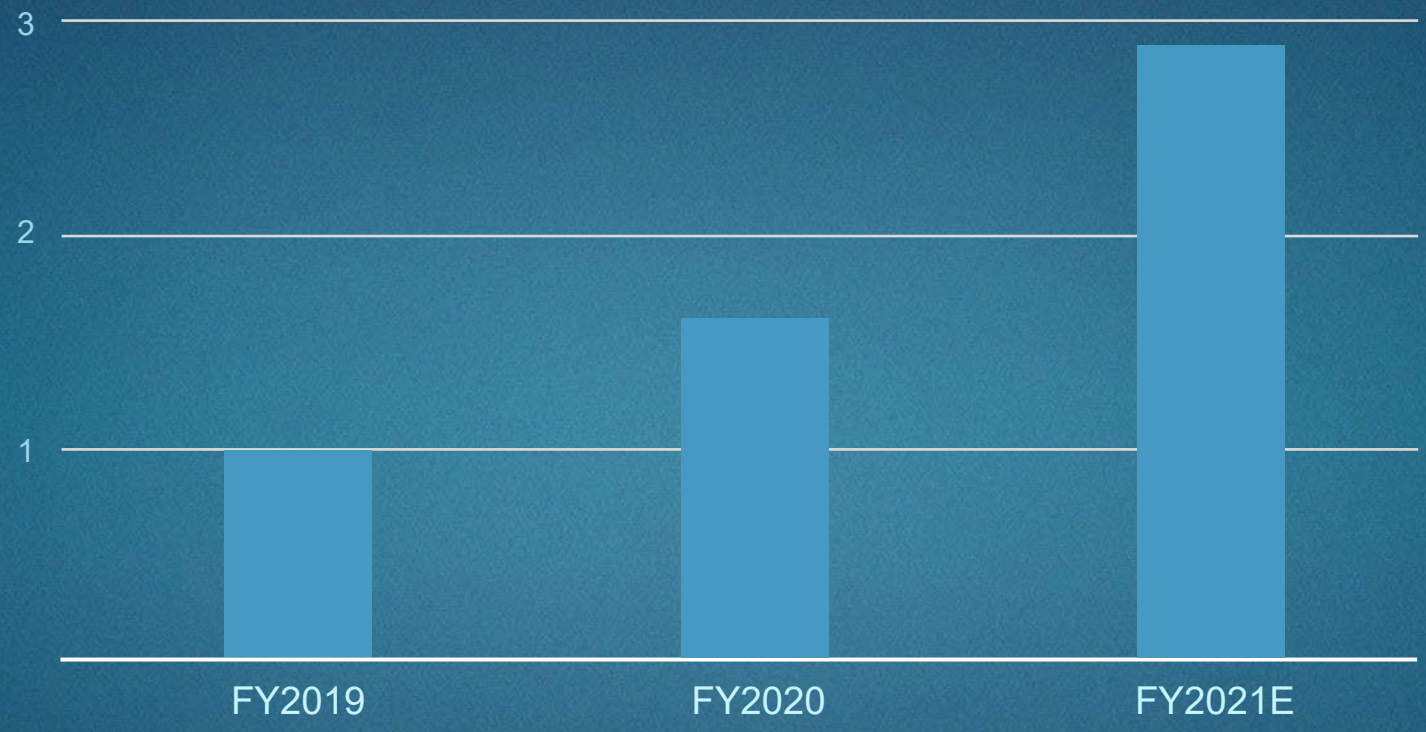


*Average revenue in each four-year period

IPC Equipment Revenue Growth



PROVision Revenue Growth



APPLIED MATERIALS®

make possible