Applications Products and Business Opportunity

Jim Koonmen
Executive Vice President
Business Line Applications

Public

Applications products and business opportunity

Key messages

The Applications business is projected to grow at ~20% CAGR with strong gross margins over the period 2020 through 2025

The Applications product portfolio supports the ASML scanner business, driven by our unique capability to help customers maximize patterning performance

- Driving improvements in Edge Placement Error (EPE)
- Delivering leading solutions for optical and e-beam metrology and inspection
- Integrating ASML's complete product portfolio into a Holistic Litho solution to optimize and control the litho process

Primary drivers of growth are the extension of our EPE roadmap:

- New metrology, inspection and control offerings extend the roadmap
- Innovative products combine computational technology, YieldStar overlay metrology and e-beam metrology
- Hardware and software products support the introduction of EUV into HVM
- New applications of deep learning in both computational litho and defect inspection drive improved performance

- **Markets and product roadmap**

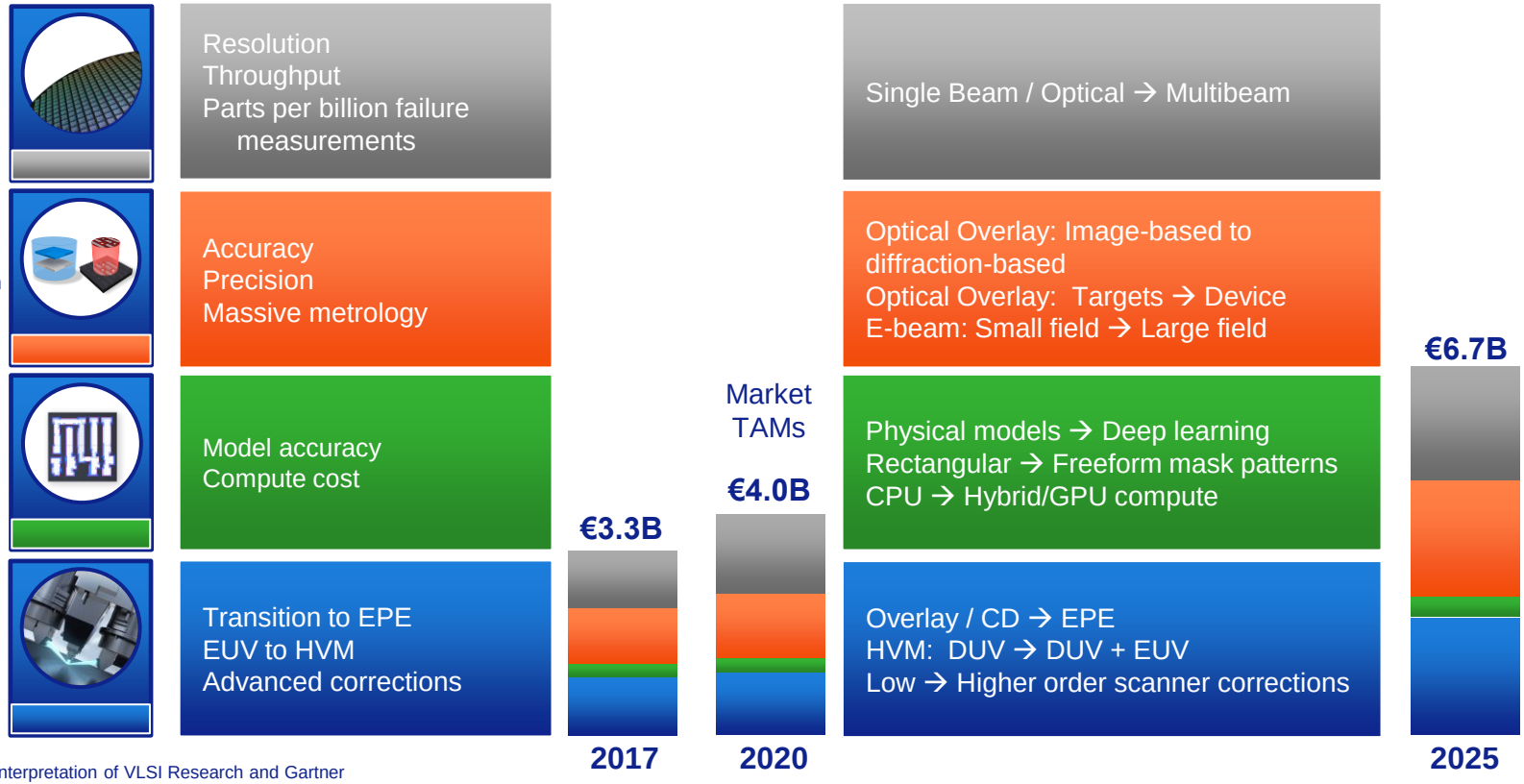
Holistic lithography

Driving improvements in EPE

E-beam inspection

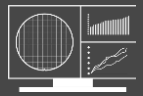
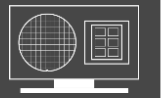
Growth opportunities in Applications arise from technology shifts in key market segments

	Industry driver	Technology shifts
High Resolution Inspection	Resolution Throughput Parts per billion failure measurements	Single Beam / Optical → Multibeam
Optical and E-beam Metrology	Accuracy Precision Massive metrology	Optical Overlay: Image-based to diffraction-based Optical Overlay: Targets → Device E-beam: Small field → Large field
Computational Lithography	Model accuracy Compute cost	Physical models → Deep learning Rectangular → Freeform mask patterns CPU → Hybrid/GPU compute
Scanner and Process Control Software	Transition to EPE EUV to HVM Advanced corrections	Overlay / CD → EPE HVM: DUV → DUV + EUV Low → Higher order scanner corrections



TAM based on ASML interpretation of VLSI Research and Gartner

Metrology, Inspection & Patterning Control Roadmap

	2020	2021	2022	2023	2024	≥ 2025
Scanner Interfaces and Control Software 	Increasing Scanner Actuation (DUV and EUV), EPE Control					
Overlay Metrology YieldStar 	Fast Stages, Multiple Wavelengths, Computational Metrology, In-Device Metrology					
E-beam Metrology 	Single Beam High Resolution, Large Field of View, Massive Metrology, EPE metrology					
E-Beam Defect Inspection 	Multi-beam, Fast and Accurate Stages, High Landing Energy, Guided Inspection					
Computational Lithography 	Improved Model Accuracy, Inverse OPC, Machine and Deep Learning, Etch Models					

Markets and product roadmap

- **Holistic lithography**

Driving improvements in EPE

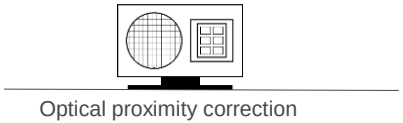
E-beam inspection

Our holistic portfolio is more important than ever

Lithography scanner with advanced control capability

Process window
Prediction and Enhancement

Process window
Control



Computational lithography and computational metrology

Optical metrology
E-beam metrology
E-beam inspection

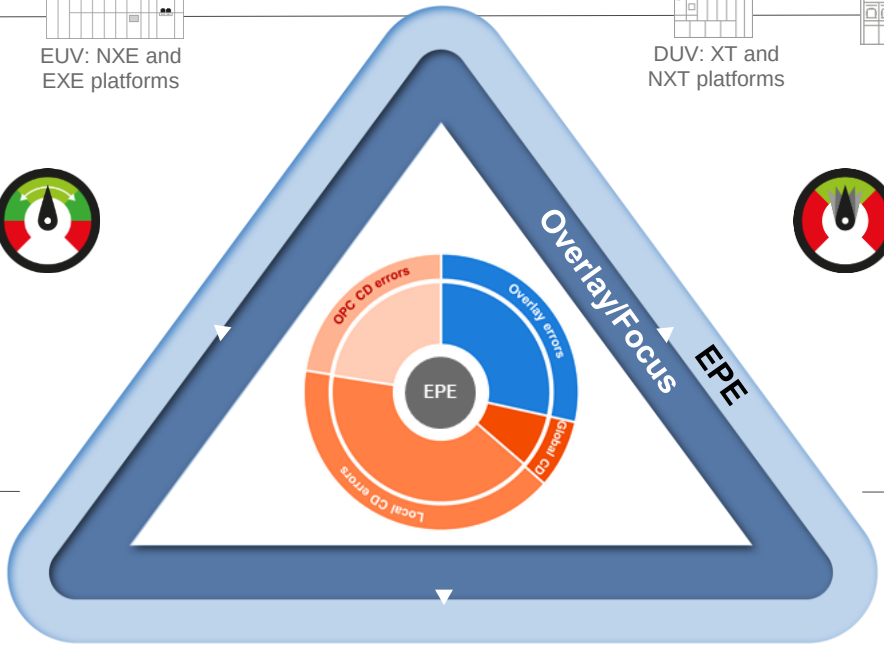
Process window
Detection

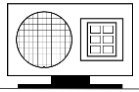
Our holistic portfolio is more important than ever

Lithography scanner with advanced control capability

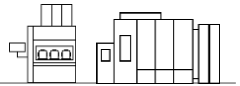
Process window
Prediction and Enhancement

Process window
Control





Optical proximity correction



YieldStar E-beam

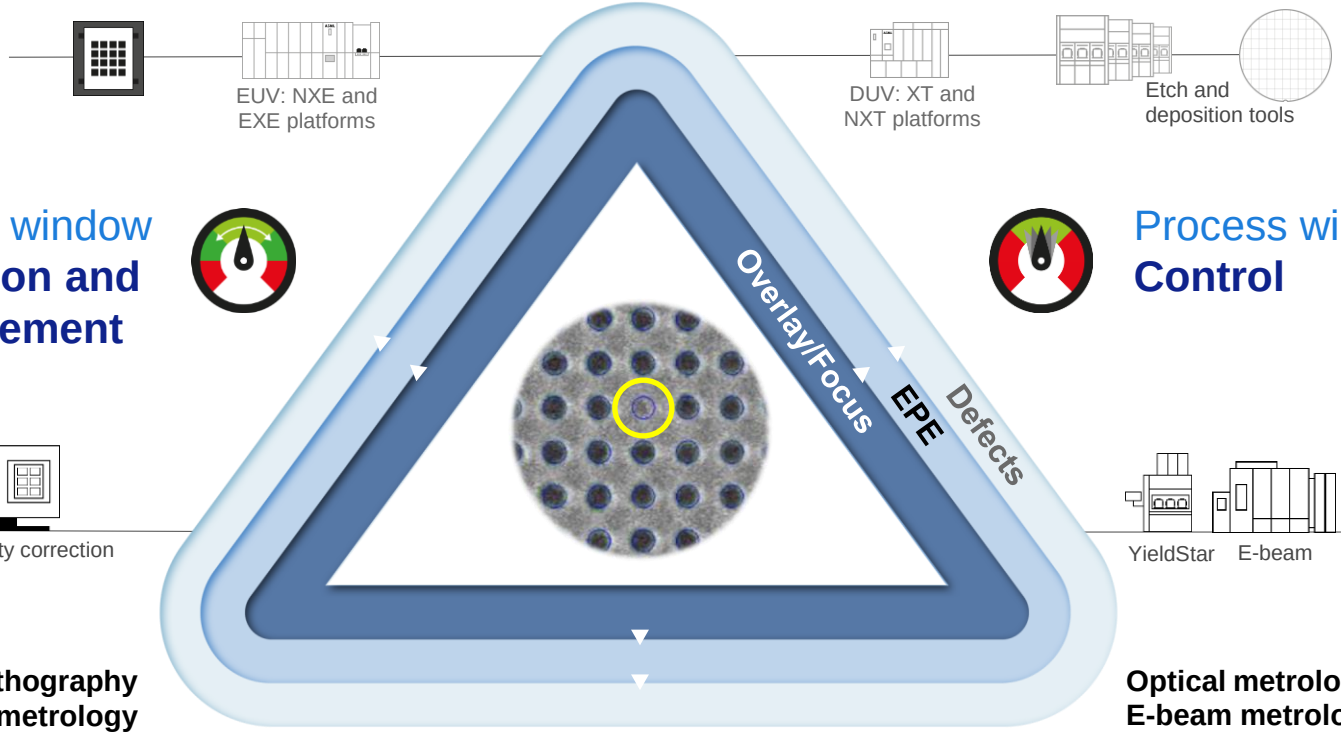
Computational lithography and computational metrology

Optical metrology
E-beam metrology
E-beam inspection

Process window
Detection

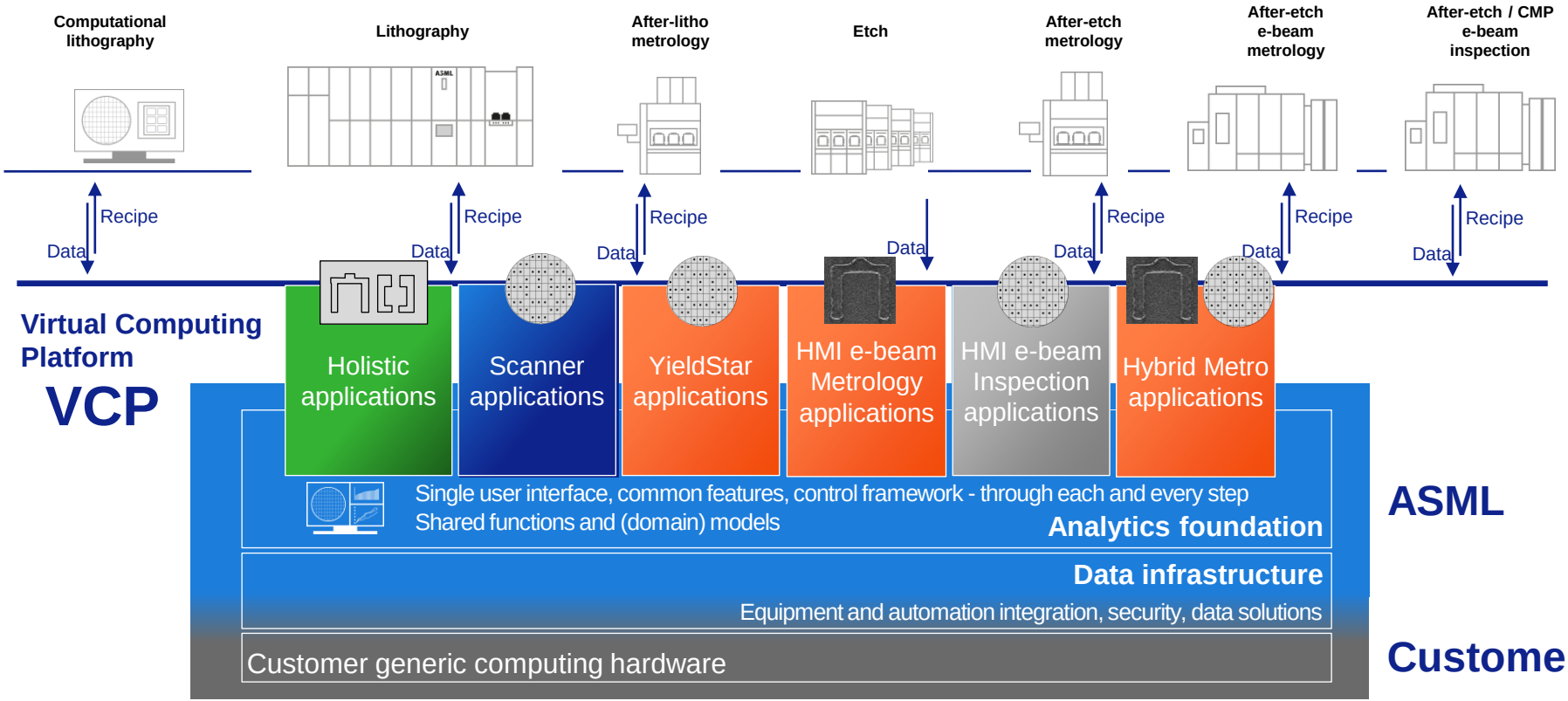
Our holistic portfolio is more important than ever

Lithography scanner with advanced control capability



All data available at every step in the flow

Use scanner metrology, YieldStar, HMI metrology and inspection to optimize sampling for scanner control, and as yield proxy for faster time-to-yield



Markets and product roadmap

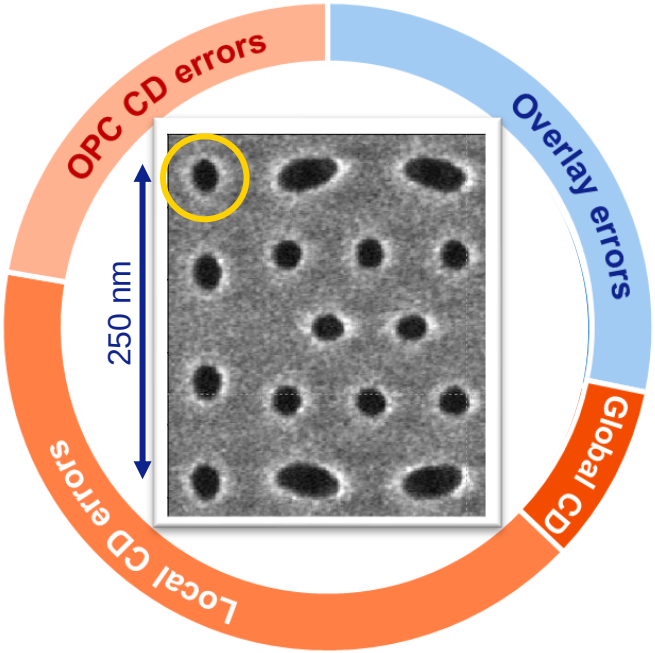
Holistic lithography

- **Driving improvements in EPE**

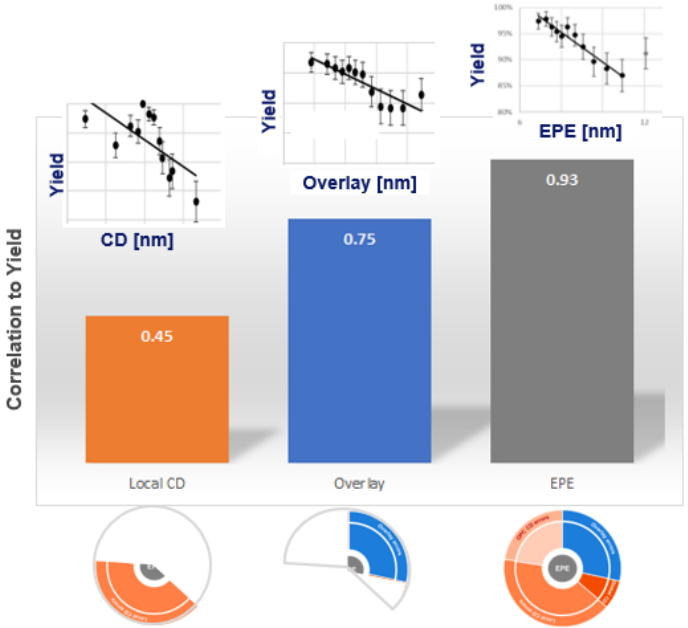
E-beam inspection

Reducing Edge Placement Error (EPE) is key to improve yield

Local CD errors, due to stochastics, become increasingly important



Edge Placement Error (EPE): combined error of overlay and CD uniformity (global CDU, local CD errors and OPC error)

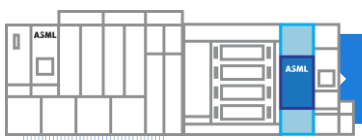


EPE is the best predictor of yield

CD: Critical Dimension, OPC: Mask Optical Proximity Correction

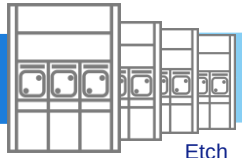
YieldStar overlay metrology – after litho and after etch

Characterizing the process error and enabling accurate feature placement



Litho

Optical overlay metrology – after Litho

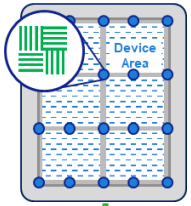


Etch

Optical overlay metrology – after Etch

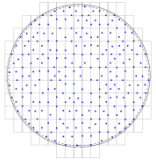
YS385

Accurate overlay on targets



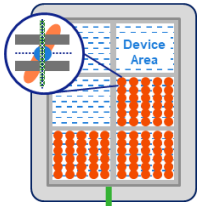
Metrology data

~800 Points x 4 wafers
Every lot



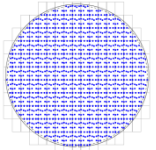
YS1385

Accurate overlay on actual device



Metrology data

~10,000 Points x 2 wafers
Every few days



Corrections

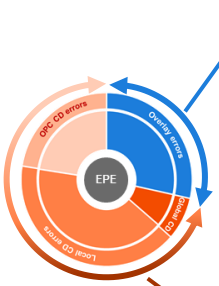
Litho overlay control: after Litho sparse + after Etch refine

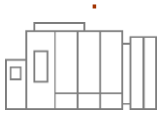
Driving improvements in EPE

Requires high fidelity, fast and accurate metrology to maximize the scanner's correction capabilities

Pattern as designed

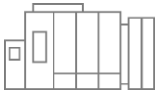
YieldStar





HMI ePx

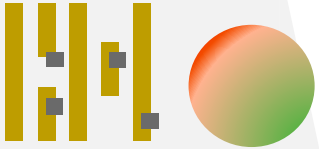
Wafer Signature



HMI ePx

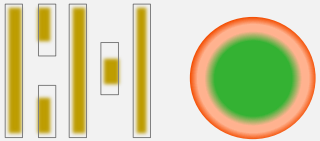
Metrology

Overlay Layer B to Layer A



>1,000 measurements/wafer <5 mins

Single layer EPE Layer A



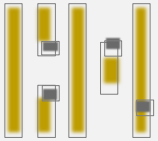
>10 million measurements/wafer 60 min

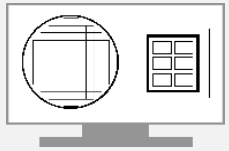
Single layer EPE Layer B

>10 million measurements/wafer 60 min

Monitoring

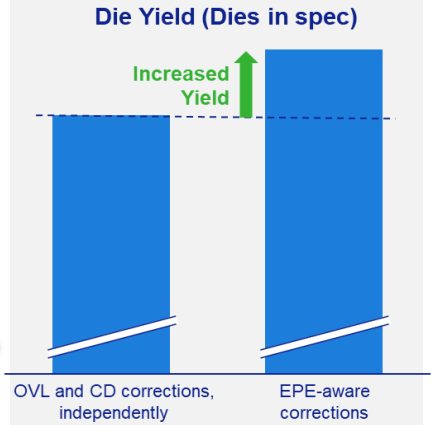
Final Dual Layer EPE

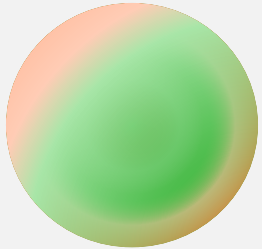




Computational EPE Control Software

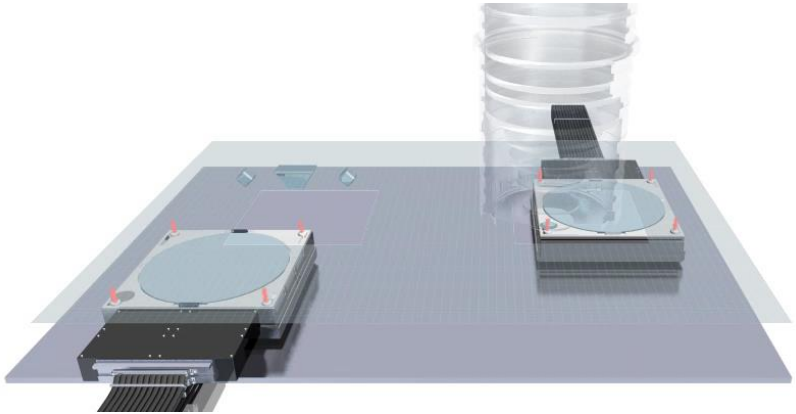
Control



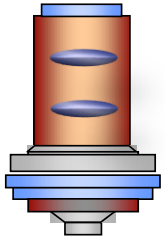


ASML scanners to improve EPE and yield

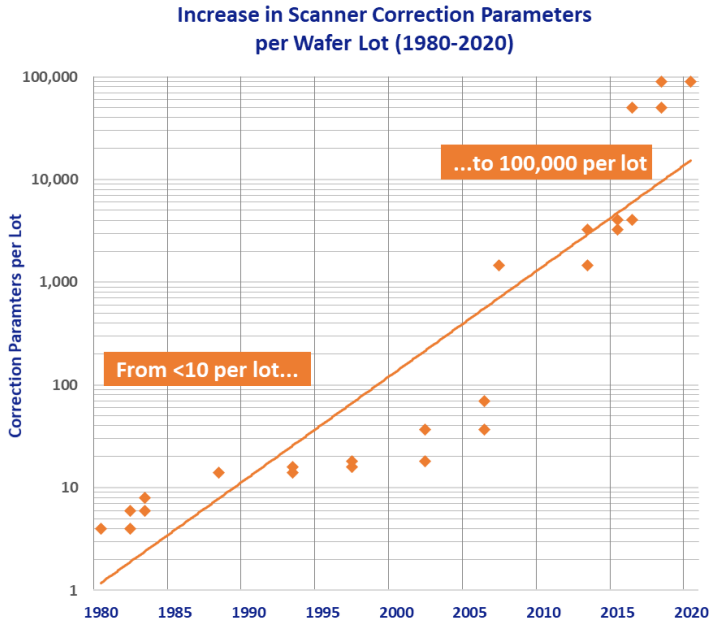
ASML scanners are uniquely able to find, measure and correct for patterning variations



Reticle stage



Wafer stage



Metrology stage

100% of wafers are measured

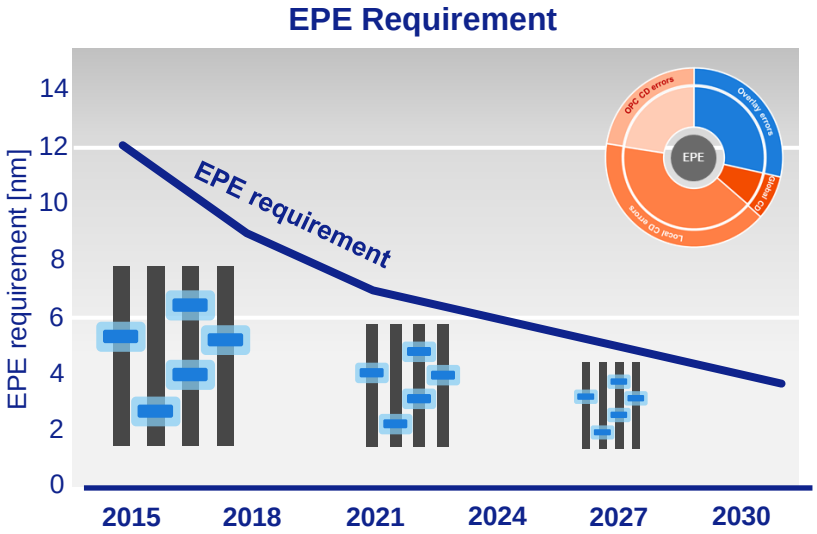
Exposure stage

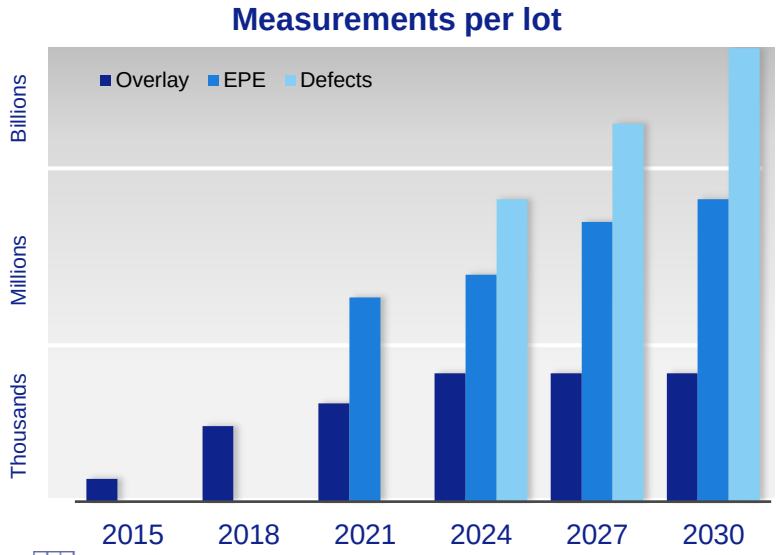
100% of wafers are processed field-by-field

Scanner actuators correct on a field-by-field basis

Tighter EPE requirements drive increased metrology

ASML provides accurate, cost-effective overlay, EPE, and defect metrology





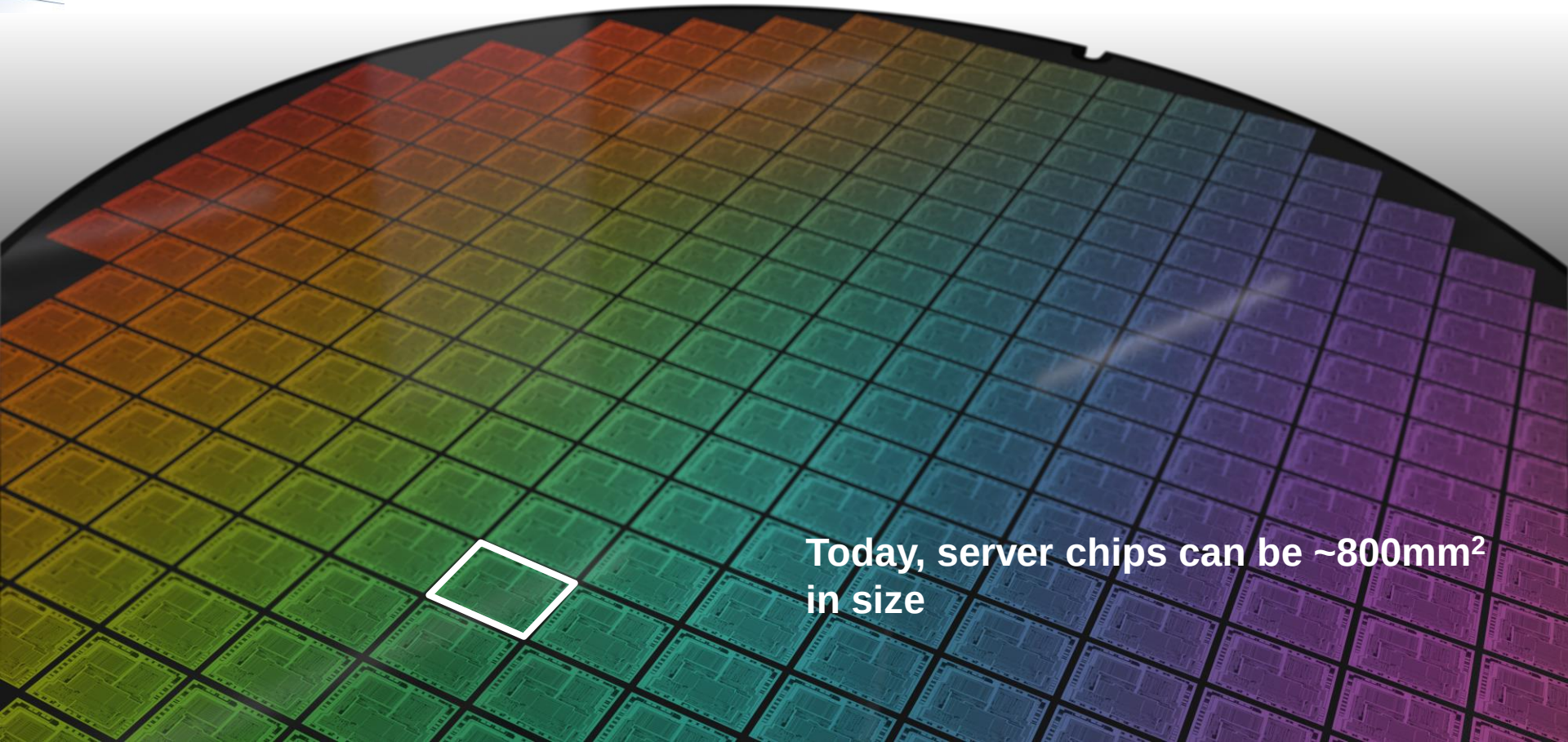
Overlay

EPE

Defect Inspection

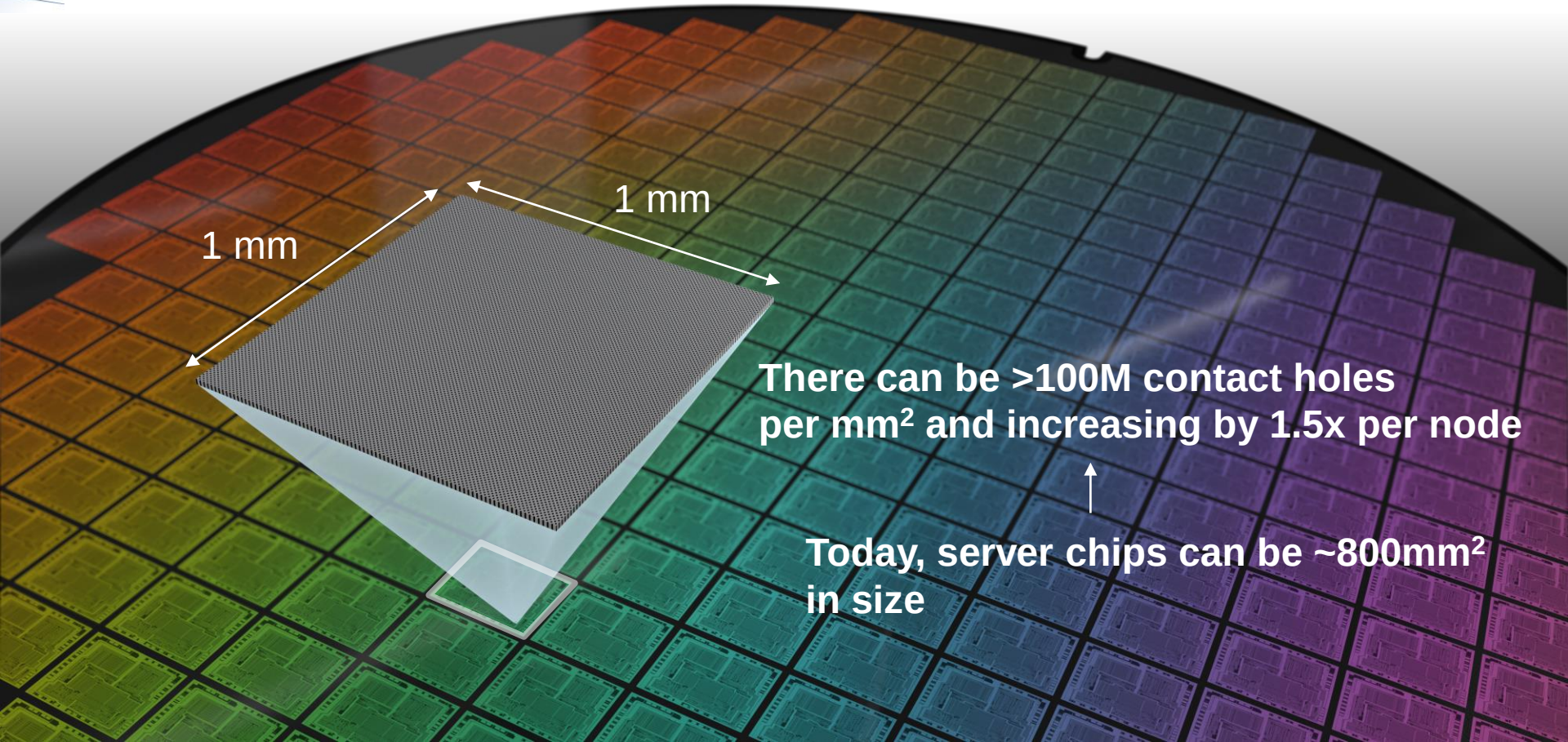
Need for part per billion control strategy

Defect-aware monitoring and control in the age of EUV stochastics



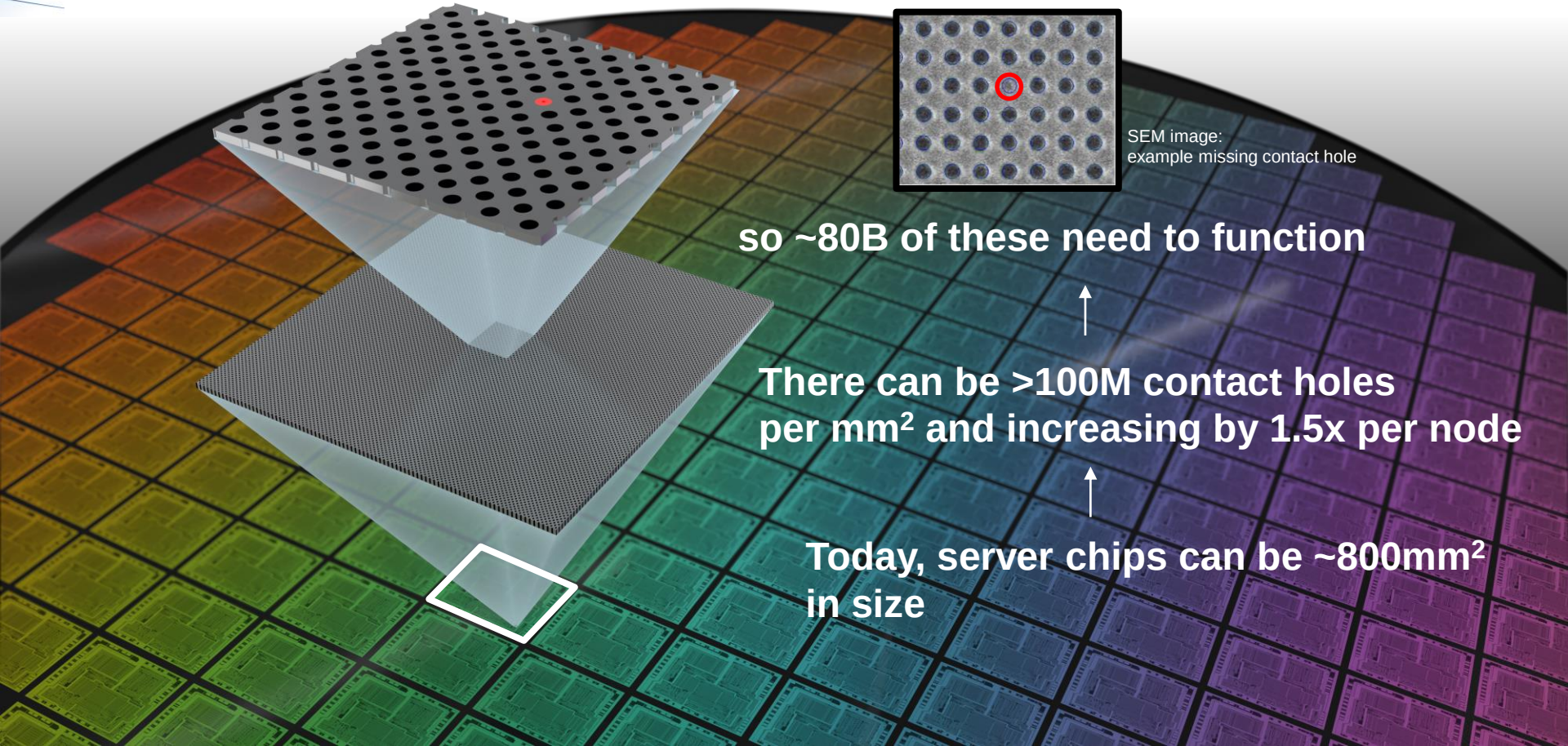
Need for part per billion control strategy

Defect-aware monitoring and control in the age of EUV stochastics



Need for part per billion control strategy

Defect-aware monitoring and control in the age of EUV stochastics



SEM image:
example missing contact hole

so ~80B of these need to function

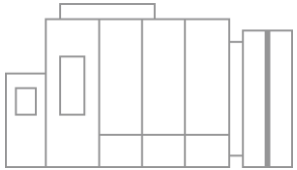
There can be >100M contact holes per mm^2 and increasing by 1.5x per node

Today, server chips can be ~800mm^2 in size

Markets and product roadmap
Holistic lithography
Driving EPE improvements
- **E-beam inspection**

High resolution E-beam versus Optical bright field inspection

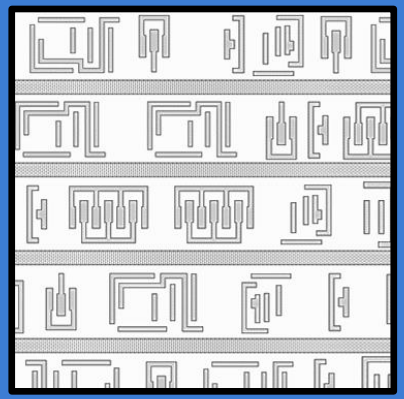
High resolution e-beam provides superior resolution to optical inspection, enabling detection of tiny pattern fidelity defects



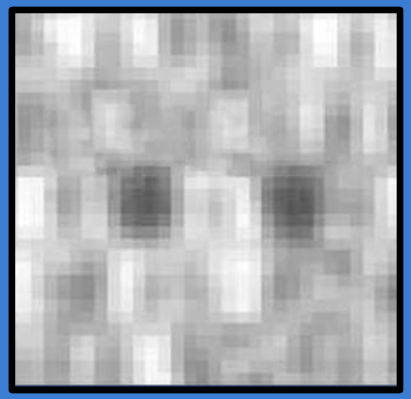
Customer design scaling down to 10nm feature size

Optical bright field inspection lacks sensitivity

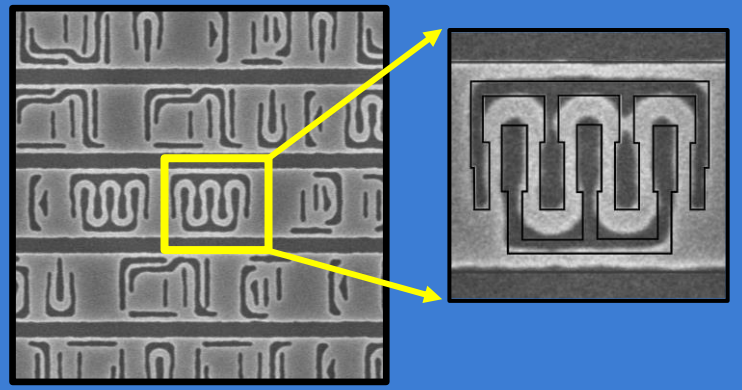
E-beam capable of capturing part per billion pattern fidelity defects with nanometer resolution



Metal layer design



Optical bright field image



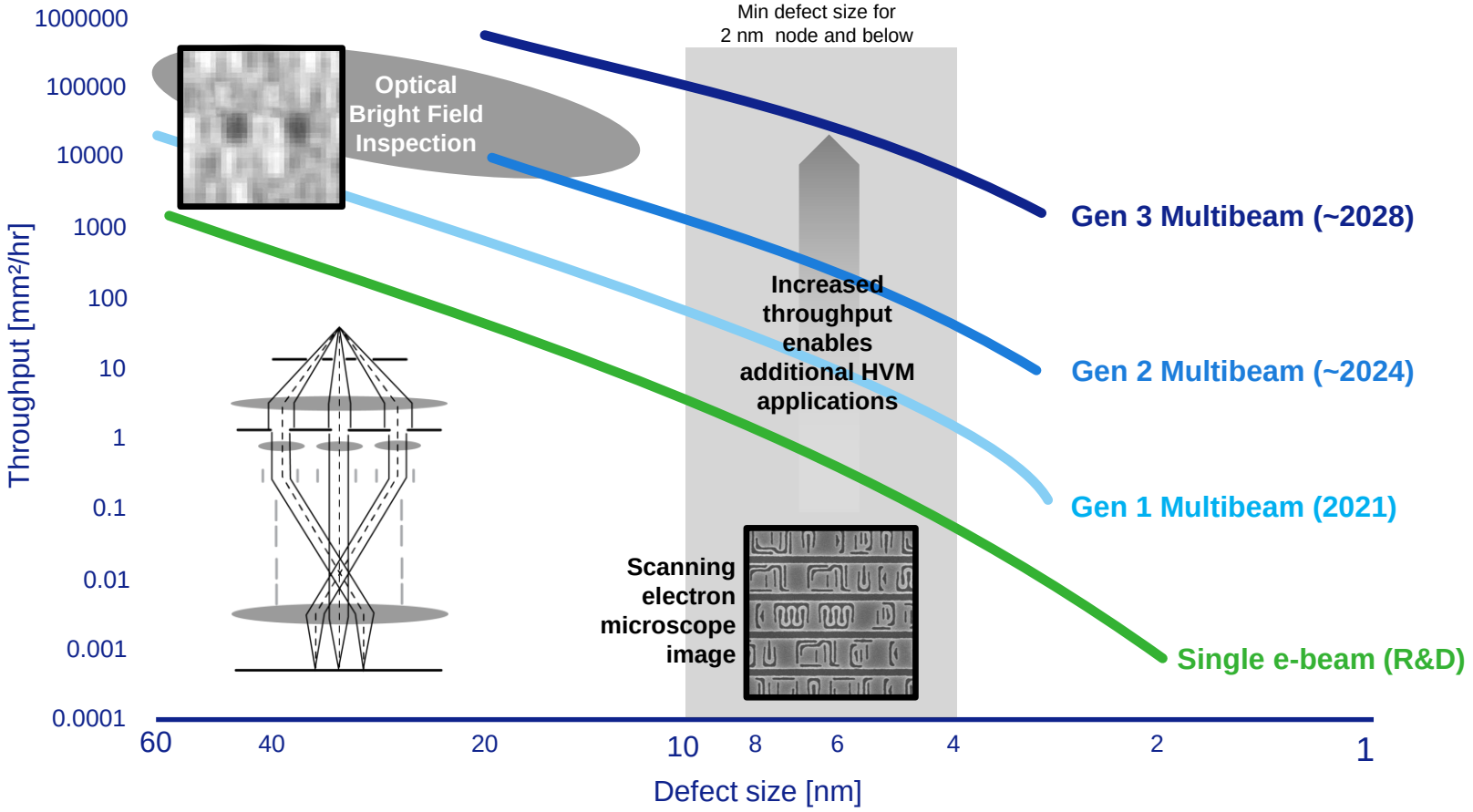
High resolution e-beam image

Design-based inspection

Proc. SPIE 9778, Metrology, Inspection, and Process Control for Microlithography, 97780O (21 April 2016)

E-beam inspection has inherent resolution advantage

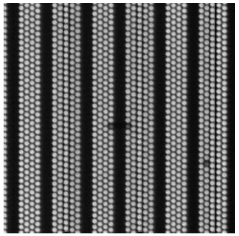
Increasing throughput through increasing parallelism with multibeam

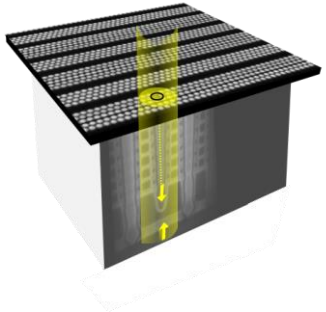


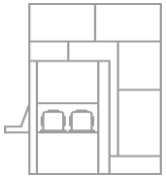
E-beam inspection: Voltage Contrast (VC) and physical defect

Unique capability of electron beam inspection to find yield limiting defects

VC inspection: detection of interlayer defects causing electric opens and shorts



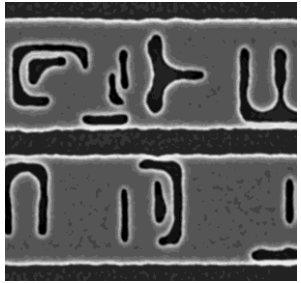


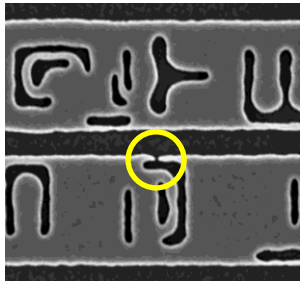


eScan

- Heavily used in DRAM and 3D NAND

Physical inspection: detection of intralayer defects such as design and process weak spots





eScan
ePx

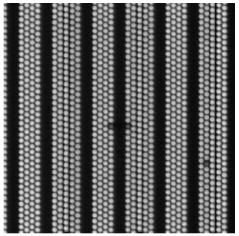
- Used in all market segments

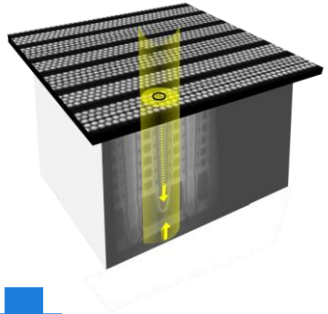
- HMI is the technology leader in e-beam inspection
- HMI leadership enabled by high current, charging control, and fast data rates

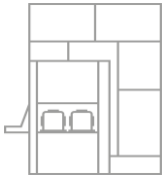
Multibeam addresses both VC and physical defect inspection

Delivering cost-effective throughput gains at high resolution

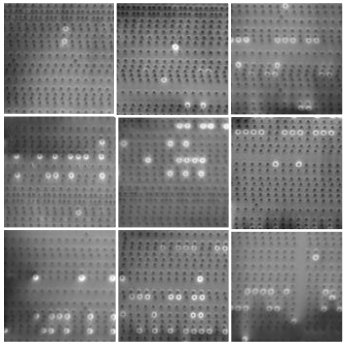
VC inspection: detection of interlayer defects causing electric opens and shorts

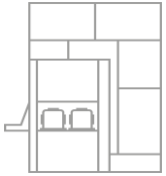






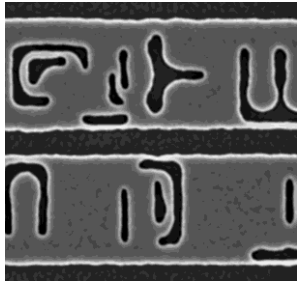
eScan

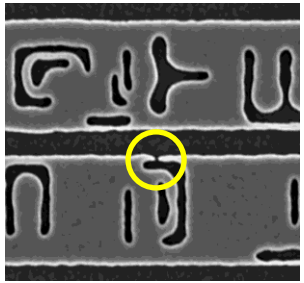




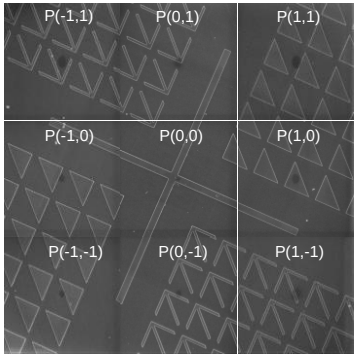
eScan
multibeam

Physical inspection: detection of intralayer defects such as design and process weak spots





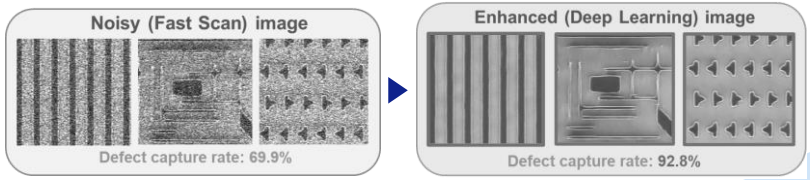
eScan
ePx



eScan
multibeam

Multibeam leverages ASML core technologies

Increasing e-beam inspection throughput for high-volume manufacturing



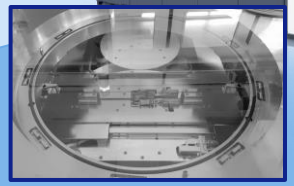
Single beam system

3 Brion's computational technology:

- Deep-learning-enabled image quality enhancement
- Design-based defect inspection

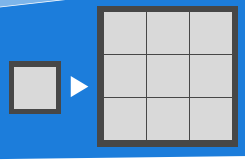
2 ASML's stage technology:

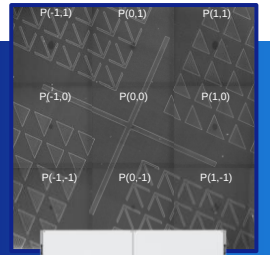
- High speed motion
- High position accuracy



Throughput

1 HMI's Advanced Electron Optics & MEMS
High quality SEM images
with 9 beams scanning simultaneously

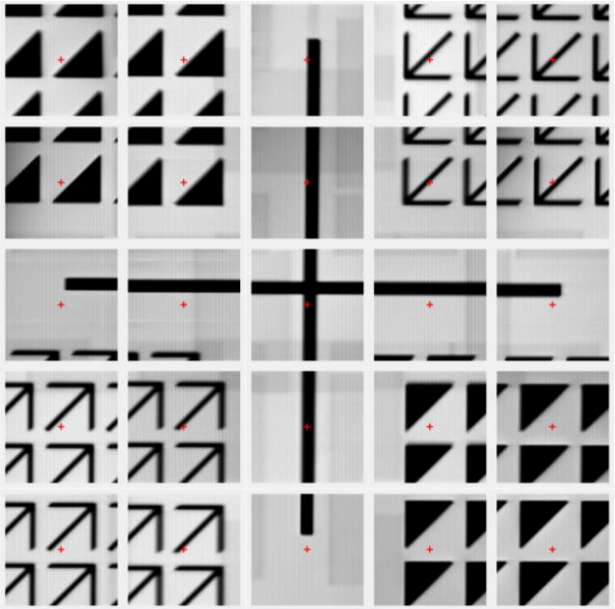




Multibeam systems now shipped and installed at customers

Multibeam: current status

Implementing learnings from eScan1000 (3x3) and driving eScan1100 (5x5) qualification for first shipment expected in Q4 2021



Imaging results from the eScan1100 5x5 multibeam system

Key messages

- Multibeam technology is challenging
- We experienced some program delays: ended original development partnership, COVID
- We added additional expertise to the team and developed new multibeam IP
- We remain confident about multibeam and are committed to realizing its market potential

Status today

- 3 eScan1000 prototypes (3x3 beams) running and under assessment at customers
- System qualification of eScan1100 (5x5 beams) moving full speed; first shipment expected Q4 2021

Applications products and business opportunity

Key messages

The Applications business is projected to grow at ~20% CAGR with strong gross margins over the period 2020 through 2025

The Applications product portfolio supports the ASML scanner business, driven by our unique capability to help customers maximize patterning performance

- Driving improvements in Edge Placement Error (EPE)
- Delivering leading solutions for optical and e-beam metrology and inspection
- Integrating ASML's complete product portfolio into a Holistic Litho solution to optimize and control the litho process

Primary drivers of growth are the extension of our EPE roadmap:

- New metrology, inspection and control offerings extend the roadmap
- Innovative products combine computational technology, YieldStar overlay metrology and e-beam metrology
- Hardware and software products support the introduction of EUV into HVM
- New applications of deep learning in both computational litho and defect inspection drive improved performance

Forward Looking Statements

This presentation contains statements that are forward-looking, including statements with respect to expected industry and business environment trends including expected growth, outlook and expected financial results, including expected net sales, gross margin, R&D costs, SG&A costs and effective tax rate, annual revenue opportunity for 2025, financial model for 2025 and assumptions and expected growth rates and drivers, expected growth including growth rates 2020-2025 and 2020-2030, total addressable market, growth opportunities beyond 2025 and expected annual growth rate in lithography and metrology and inspection systems and expected annual growth rate in installed base management, expected trends in addressable market up to 2030, expected trends in Logic and Memory revenue opportunities, long term growth opportunities and outlook, expected trends in demand and demand drivers, expected benefits and performance of systems and applications, semiconductor end market trends, expected growth in the semiconductor industry including expected demand growth and capital spend in coming years, expected wafer demand growth and investments in wafer capacity, expected lithography market demand and growth and spend, growth opportunities and drivers, expected trends in EUV and DUV demand, sales, outlook, roadmaps, opportunities and capacity growth and expected EUV adoption, profitability, availability, productivity and output and estimated wafer demand and improvement in value, expected trends in the applications business, expected trends in installed base management including expected revenues and target margins, expected trends and growth opportunity in the applications business, expectations with respect to high-NA, the expectation of increased output capacity, plans, strategies and strategic priorities and direction, expectation to increase capacity, output and production to meet demand, the expectation that Moore's law will continue and Moore's law evolution, product, technology and customer roadmaps, and statements and intentions with respect to capital allocation policy, dividends and share buybacks, including the intention to continue to return significant amounts of cash to shareholders through a combination of share buybacks and growing annualized dividends and statements with respect to ESG commitment, sustainability strategy, targets, initiatives and milestones. You can generally identify these statements by the use of words like "may", "will", "could", "should", "project", "believe", "anticipate", "expect", "plan", "estimate", "forecast", "potential", "intend", "continue", "target", "future", "progress", "goal" and variations of these words or comparable words. These statements are not historical facts, but rather are based on current expectations, estimates, assumptions and projections about our business and our future financial results and readers should not place undue reliance on them. Forward-looking statements do not guarantee future performance and involve a number of substantial known and unknown risks and uncertainties. These risks and uncertainties include, without limitation, economic conditions; product demand and semiconductor equipment industry capacity, worldwide demand and manufacturing capacity utilization for semiconductors, semiconductor end-market trends, the impact of general economic conditions on consumer confidence and demand for our customers' products, performance of our systems, the impact of the COVID-19 outbreak and measures taken to contain it on the global economy and financial markets, as well as on ASML and its customers and suppliers, and other factors that may impact ASML's sales and gross margin, including customer demand and ASML's ability to obtain supplies for its products, the success of R&D programs and technology advances and the pace of new product development and customer acceptance of and demand for new products, production capacity and our ability to increase capacity to meet demand, the number and timing of systems ordered, shipped and recognized in revenue, and the risk of order cancellation or push out, production capacity for our systems including the risk of delays in system production and supply chain capacity, constraints, shortages and disruptions, trends in the semi-conductor industry, our ability to enforce patents and protect intellectual property rights and the outcome of intellectual property disputes and litigation, availability of raw materials, critical manufacturing equipment and qualified employees and trends in labor markets, geopolitical factors, trade environment; import/export and national security regulations and orders and their impact on us, ability to meet sustainability targets, changes in exchange and tax rates, available liquidity and liquidity requirements, our ability to refinance our indebtedness, available cash and distributable reserves for, and other factors impacting, dividend payments and share repurchases, results of the share repurchase programs and other risks indicated in the risk factors included in ASML's Annual Report on Form 20-F for the year ended December 31, 2020 and other filings with and submissions to the US Securities and Exchange Commission. These forward-looking statements are made only as of the date of this document. We undertake no obligation to update any forward-looking statements after the date of this report or to conform such statements to actual results or revised expectations, except as required by law.

ASML Small Talk 2021

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