Chips industry, ASML and Photonics & Optics

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September 21, 2022, Veldhoven

Public

- Chips industry drivers
- ASML
- Photonics & Optics

Chip Industry Drivers

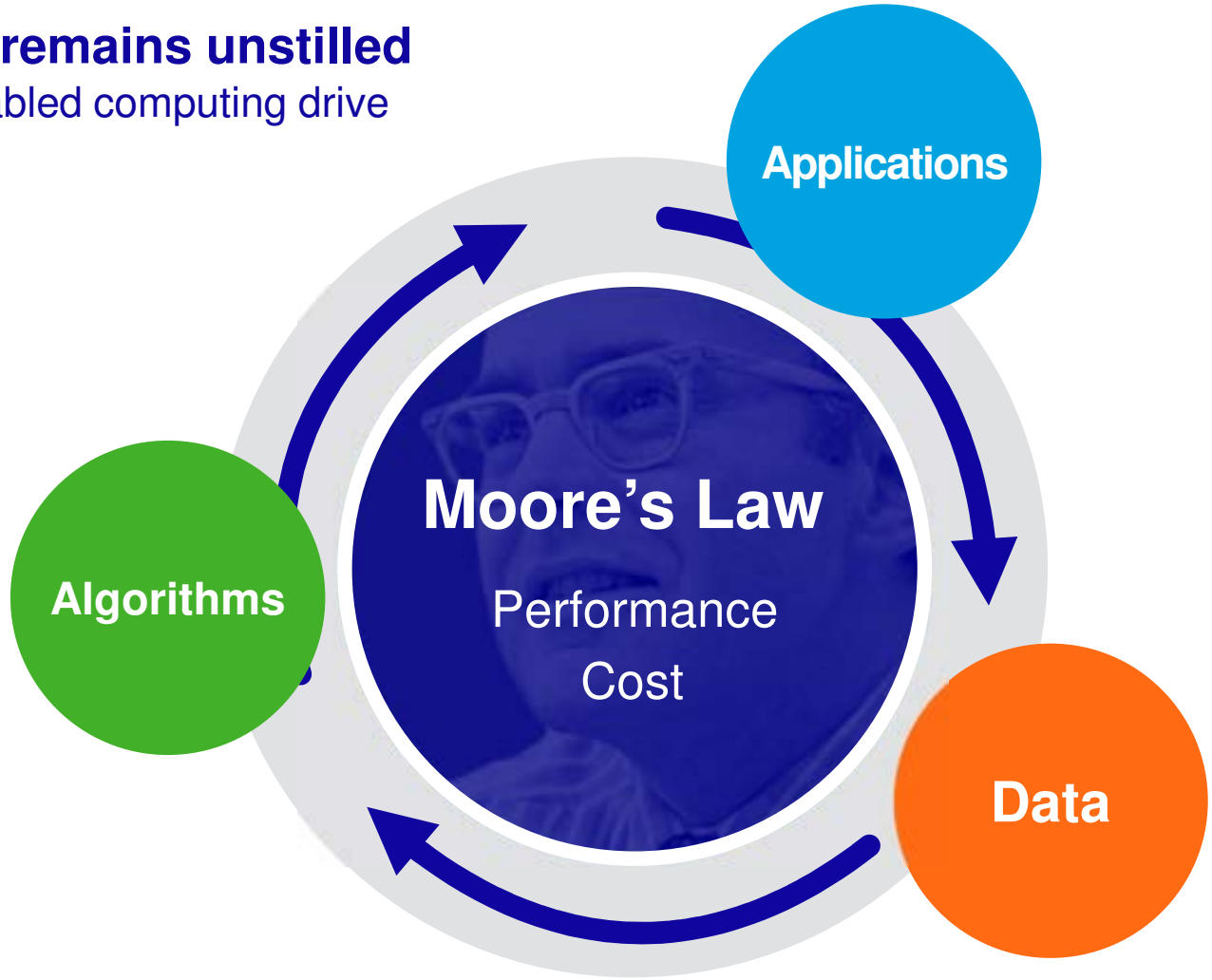
Society's hunger for chips remains unstilled

Major trends in semiconductor-enabled computing drive long term demand

Applications
- Autonomous decisions
- Immersive resolution
- On-device Artificial Intelligence
- Virtual / augmented reality

Data
- 5G connectivity
- Real-time latency
- Growing data volumes

Algorithms
- From big data to value
- Enhanced processing
- Deep learning



Transitioning from mobile to ubiquitous computing

175 ZB

Data created per year by[1]

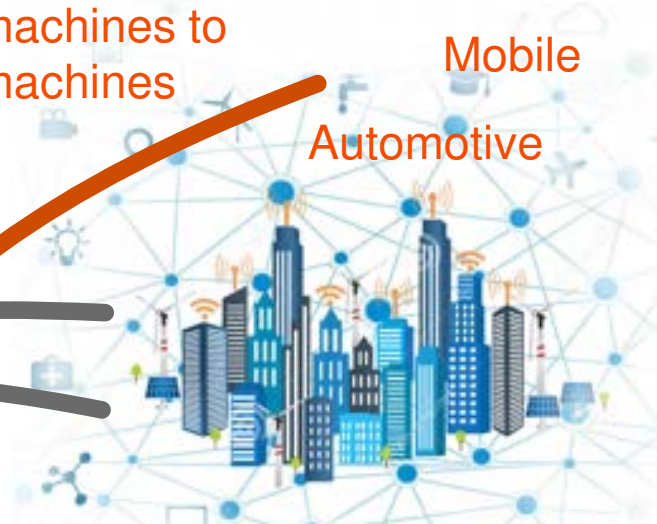
symbool	naam	waarde
kB	kilobyte	$1000^1 = 10^3$
MB	megabyte	$1000^2 = 10^6$
GB	gigabyte	$1000^3 = 10^9$
TB	terabyte	$1000^4 = 10^{12}$
PB	petabyte	$1000^5 = 10^{15}$
EB	exabyte	$1000^6 = 10^{18}$
ZB	zettabyte	$1000^7 = 10^{21}$
YB	yottabyte	$1000^8 = 10^{24}$

Mainframe computing
Multiple persons to one machine

Personal co
One person to one machine

mputing
to multiple

Ubiquitous computing
Multiple machines to multiple machines



Mobile

Automotive

High Performance Computing

Internet of Things

Product Unit [Mu]

100,000
10,000
1,000
100
10
1
0.1
0.01

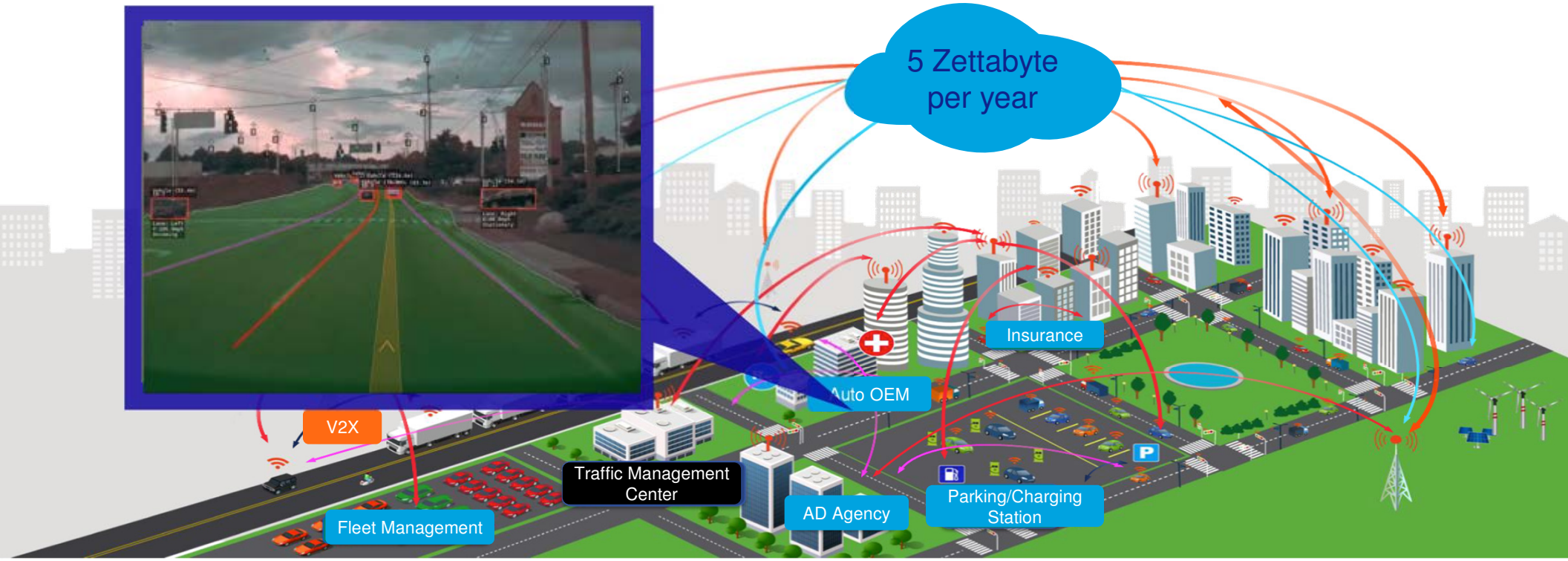
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040

[1]David Reijnsel, John Gantz, John Rydning, IDC, Data age 2025, The digitization of the world from edge to core, Nov 2018

Source: Min Cao, TSMC, "Semiconductor Innovation and Scaling, a foundry perspective", China Semiconductor Technology Conference, Shanghai, March 2019

Smart Cities & Autonomous Cars to create 5 ZB per year

with data value of $450B to $700B by 2030



Automotive sensors are mapping the world in millions of data points per second, enabling the road to autonomous driving

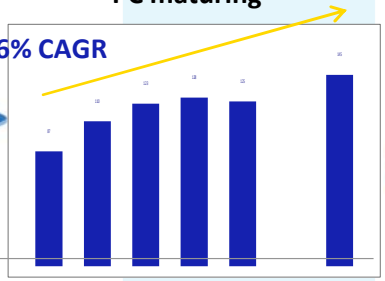
Source: Russel Ruben, Western Digital | Flash Memory Summit 2018, Santa Clara, CA – McKinsey - 2030

End market growth drives opportunities

Chips are everywhere

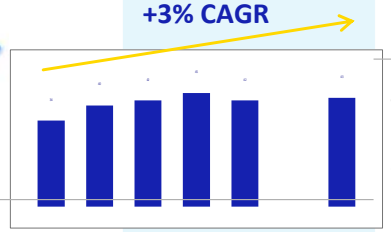
Mobile and PC maturing

+6% CAGR



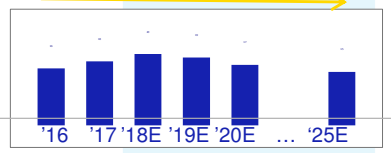
Tablets, B$

+3% CAGR



PCs, B$

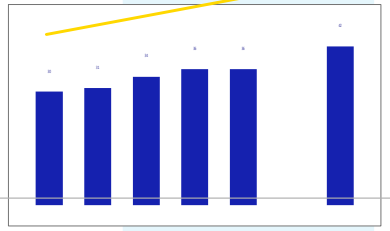
-1% CAGR



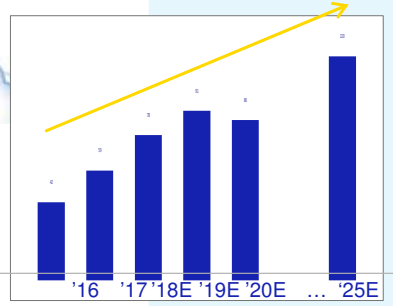
Servers, Datacenters & Storage, B$

Continued growth in cloud applications

+4% CAGR



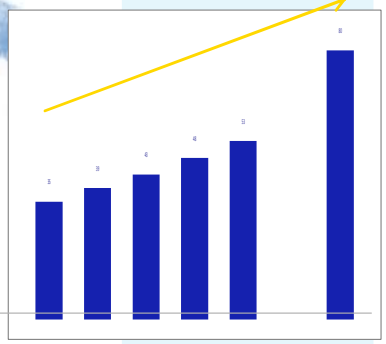
+12% CAGR



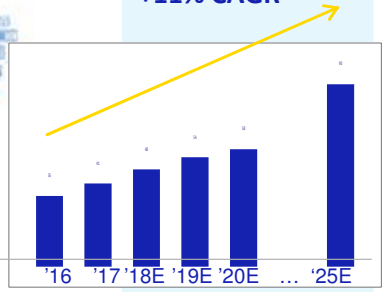
Industrial Electronics, B$

Emerging connected devices market

+10% CAGR

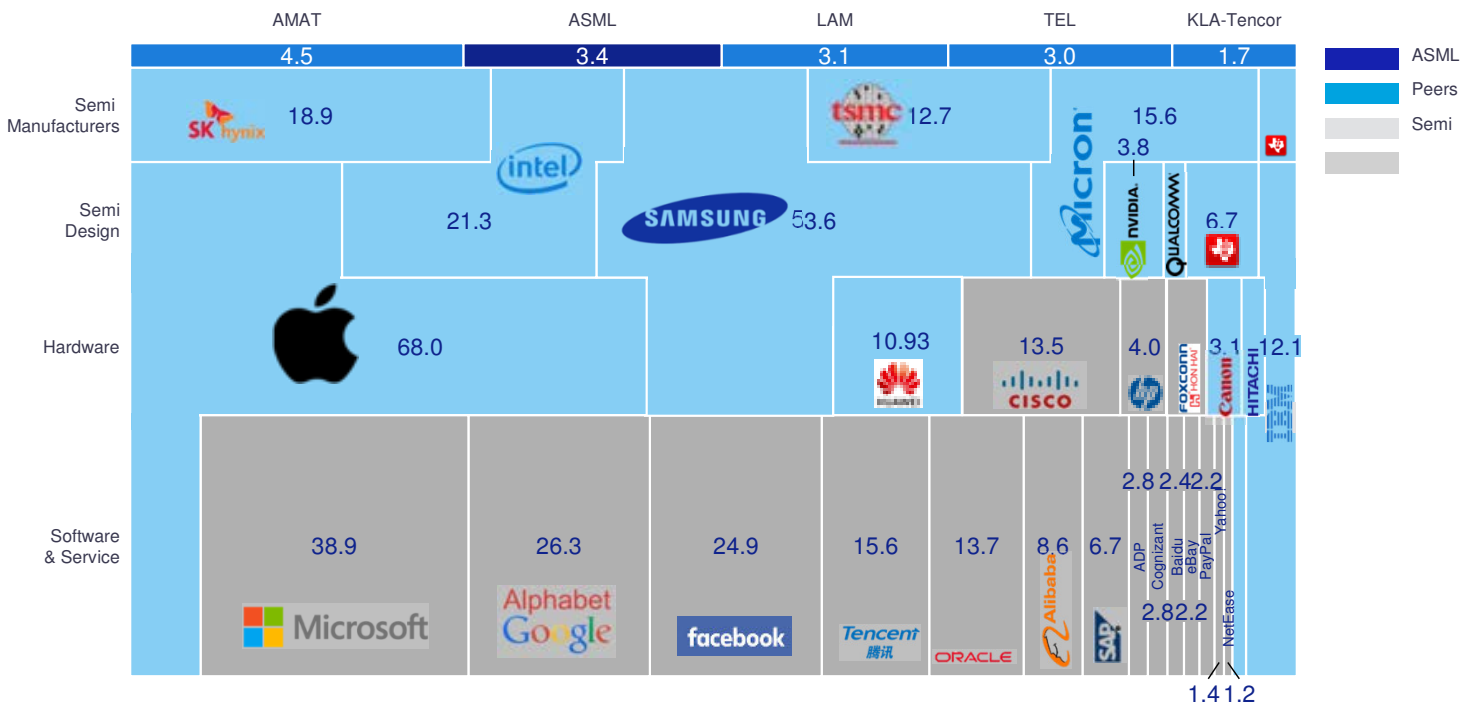


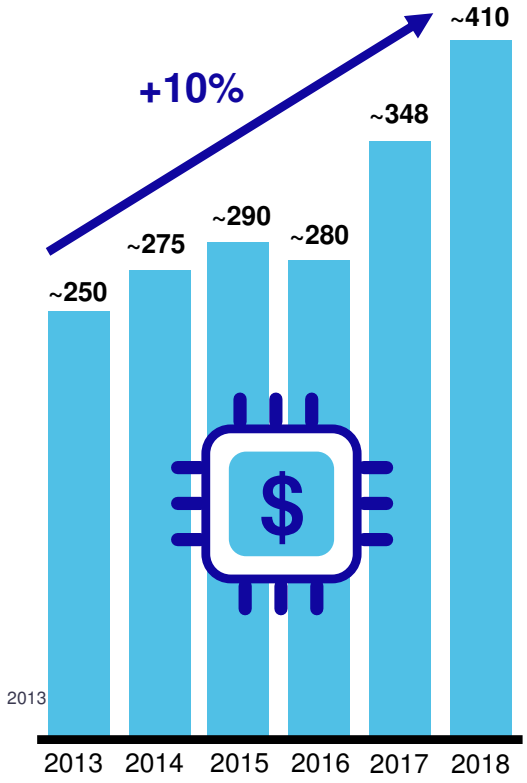
+11% CAGR



Our industry ecosystem has considerable means with strong incentives to compete and drive innovation

Top technology companies in our ecosystem (EBIT CY 2018 B$)



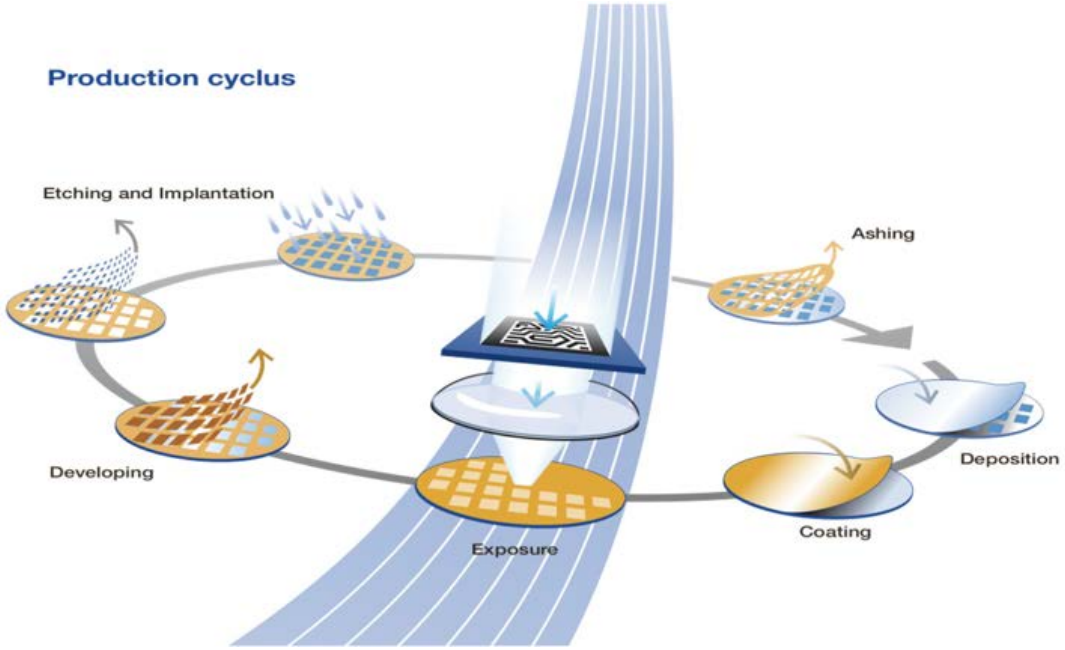


Source: Bloomberg (GICS 45 classification, out of the Top 50 companies of the classification)

ASML & the Role of Lithography

The chip in your smartphone

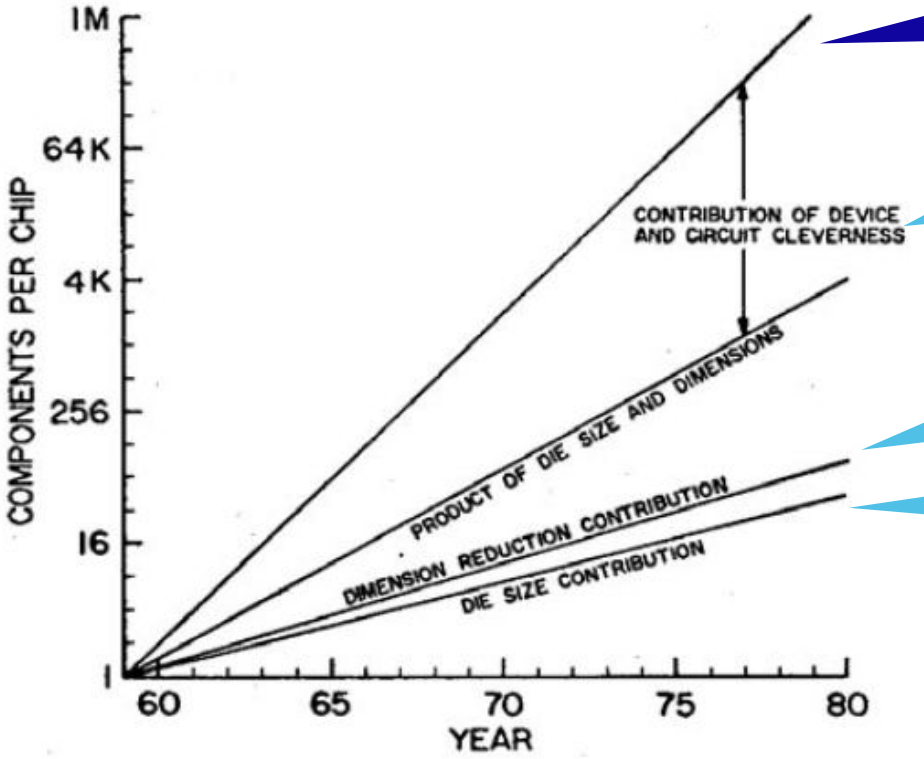
How chips are produced



- Integrated Circuits are made on 300 mm silicon wafers.
- Lithography exposes a pattern on a wafer.
- A wafer goes through many tens of cycles: deposit → expose → etch → …
- Important lithography parameters are
  - **Imaging**: print 15 nm lines
  - **Overlay**: print a pattern within 2 nm on top of a pattern printed a few days earlier
  - **Productivity**: print ~125 images per wafer at a speed of 200+ wafers/hr

Moore's Law enabled by multiple drivers

Area shrink has always been one of multiple enablers



Trend observed by Moore in his 1965 paper "Moore's Law"

"Device and circuit cleverness" explains ~1/3

Shrink => "Dimensional reductions" explains ~1/3

"Die size increase" explains ~1/3

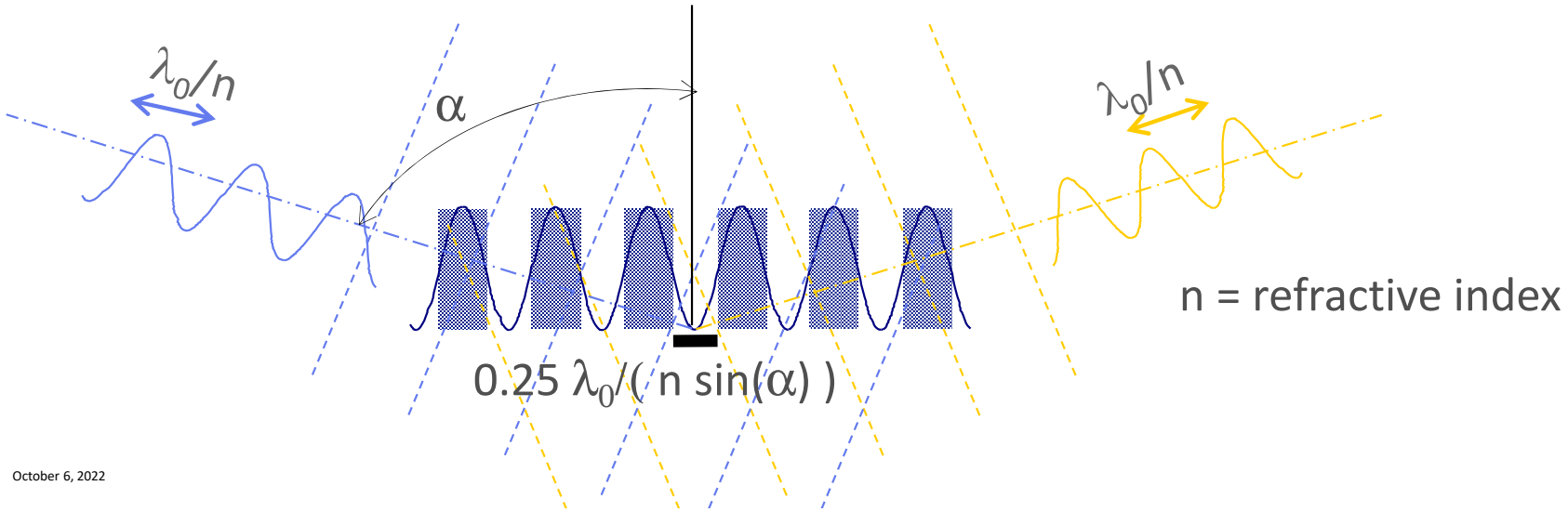
Resolution optical lithography

Resolution is driven by the Rayleigh formula: $CD = k_1 * \lambda / NA$

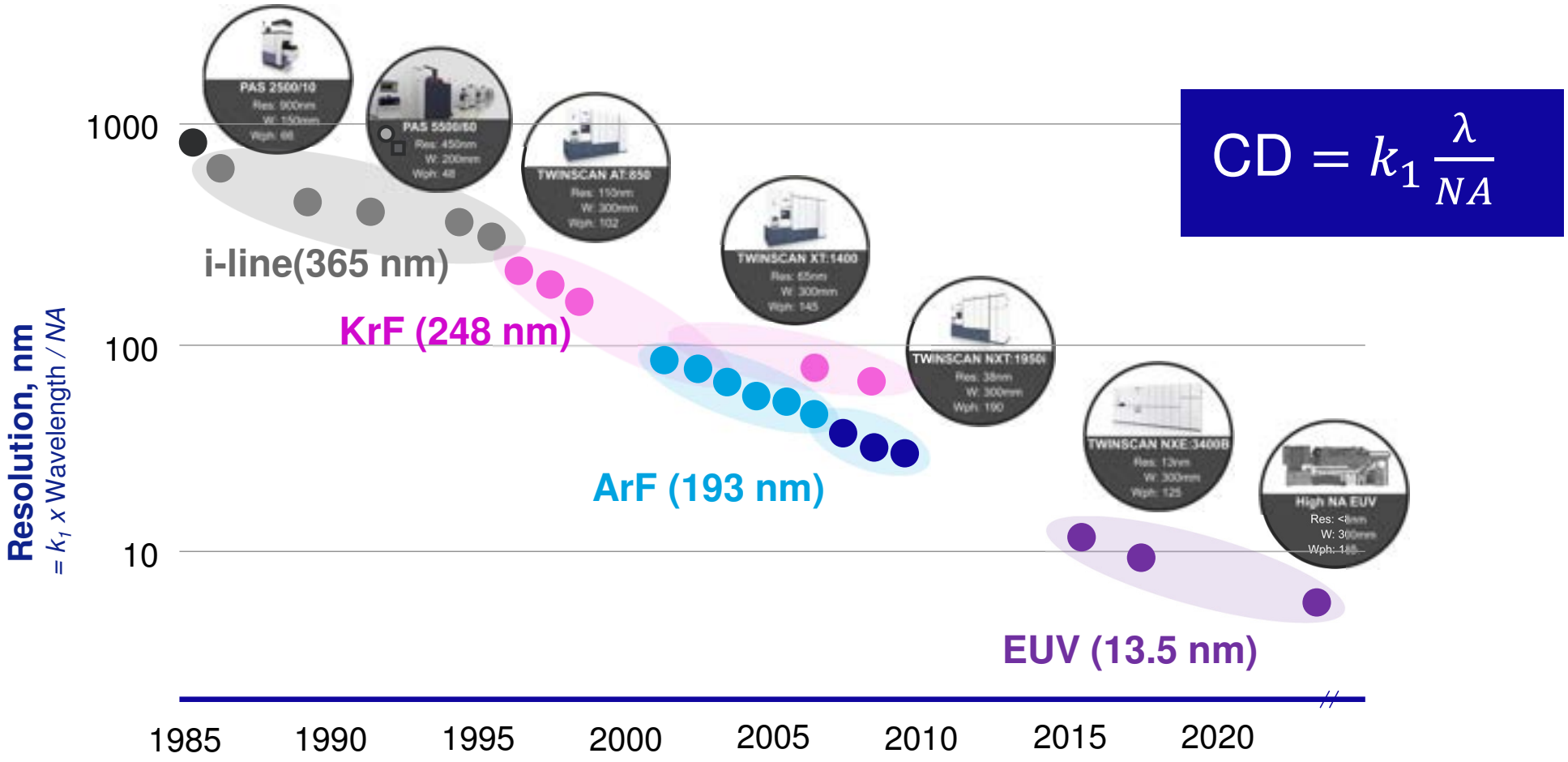
Whereby:

- CD = Critical Dimension = half period of smallest printable feature
- λ = wavelength of light
- NA = numerical aperture of optics = n * sin(α)
- k_1 = Lithography process improvements: tool & mask & resist

Single exposure: minimum $k_1 = 0.25$



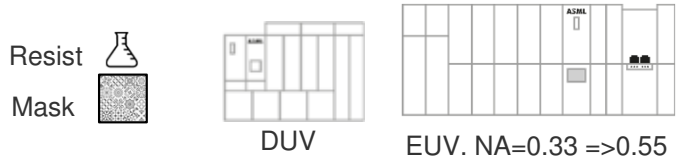
Historic trend litho resolution

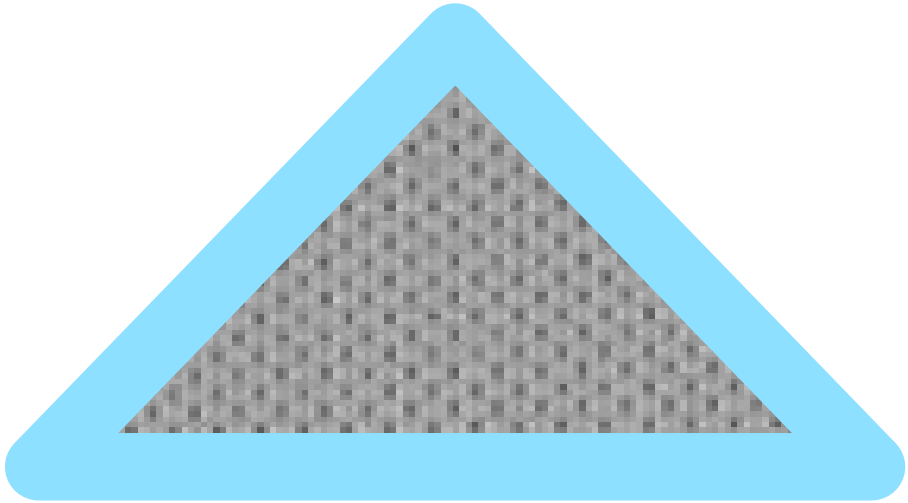


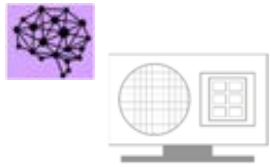
Optics & Photonics

Where does Optics play a role?

Lithography scanner with advanced control capability







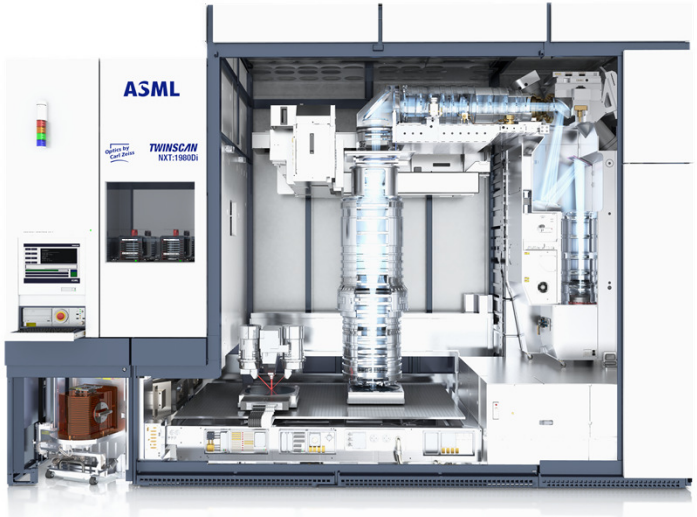
Deep Learning Algorithms

Computational lithography and metrology

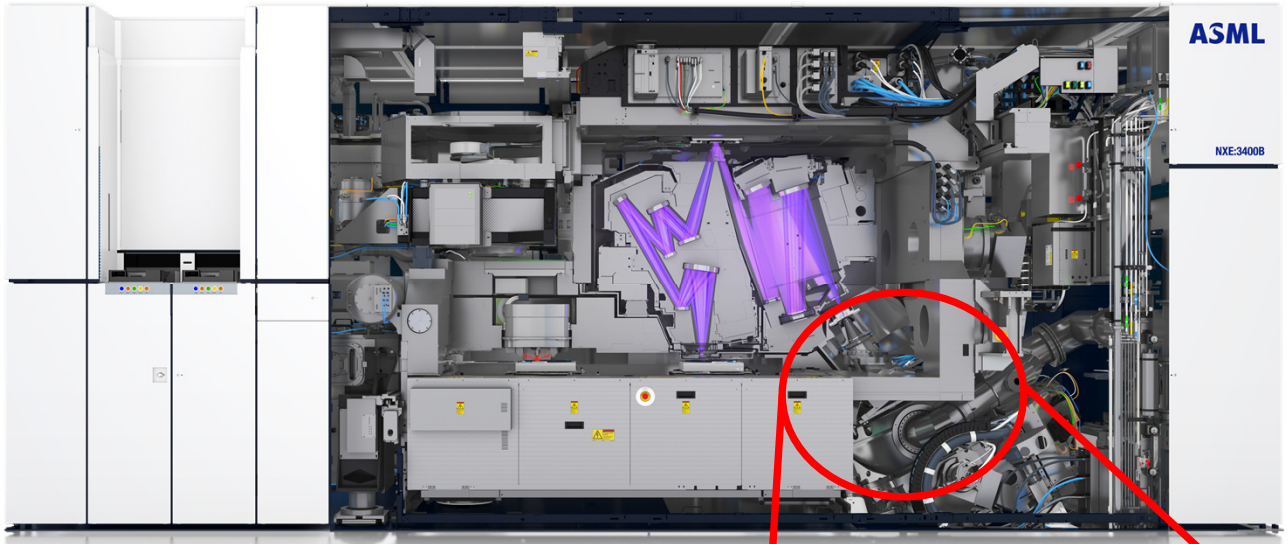
YieldStar E-beam

Optical and e-beam metrology and inspection

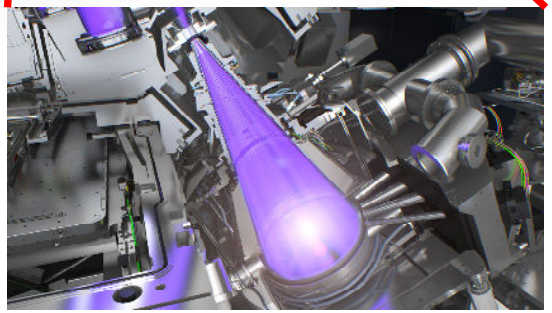
Lithography Scanner



DUV – NXT systems



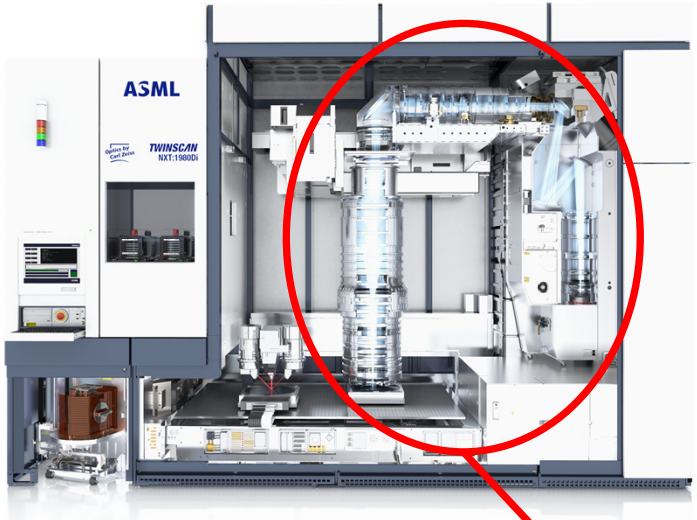
EUV – NXE systems



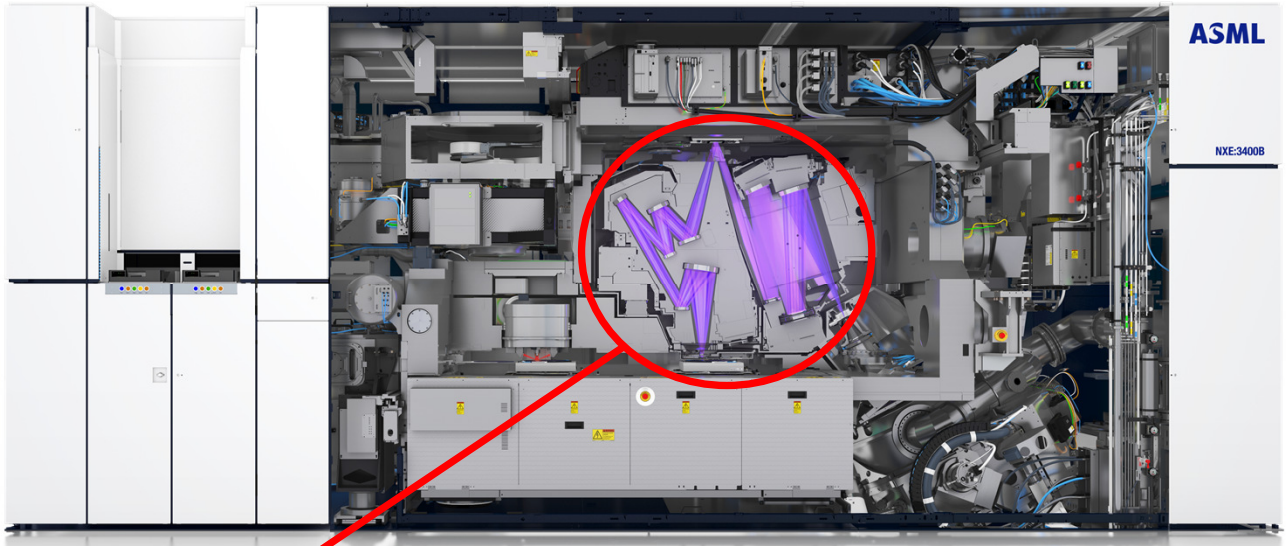
EUV Light Source

Public

Lithography Scanner



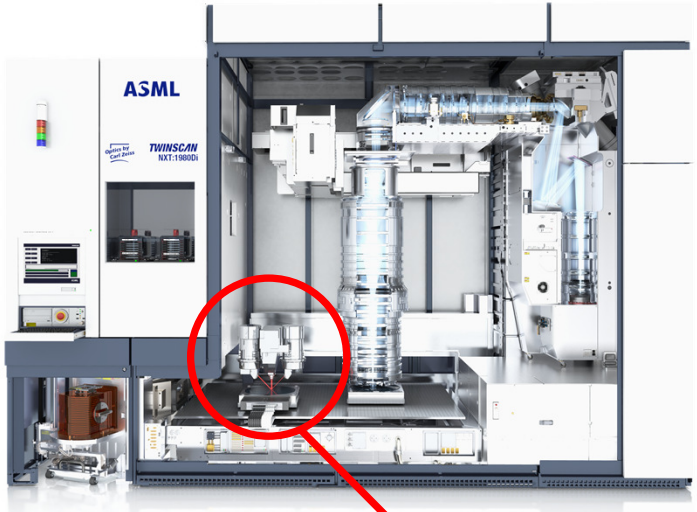
DUV – NXT systems



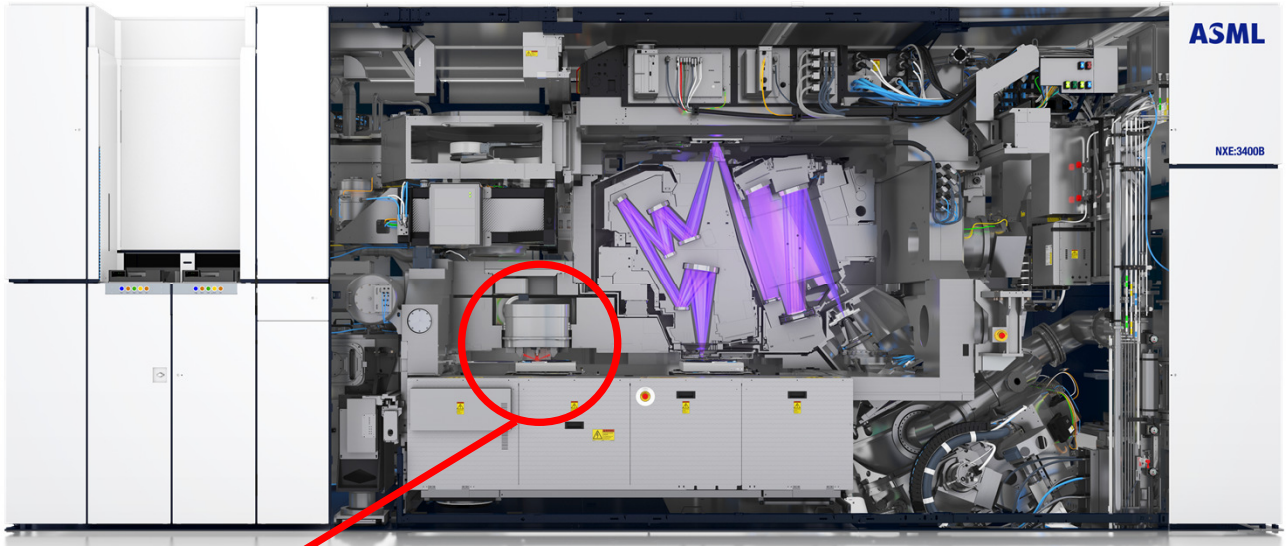
EUV – NXE systems

Illumination &
Projection Optics

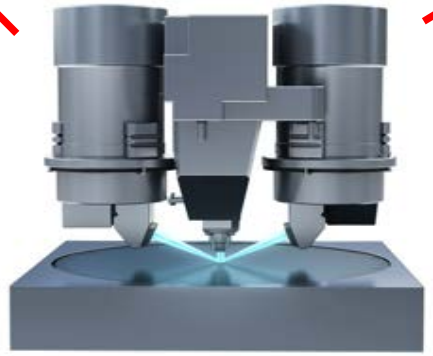
Lithography Scanner



DUV – NXT systems



EUV – NXE systems



Measurement Systems for x-y-z Measurements

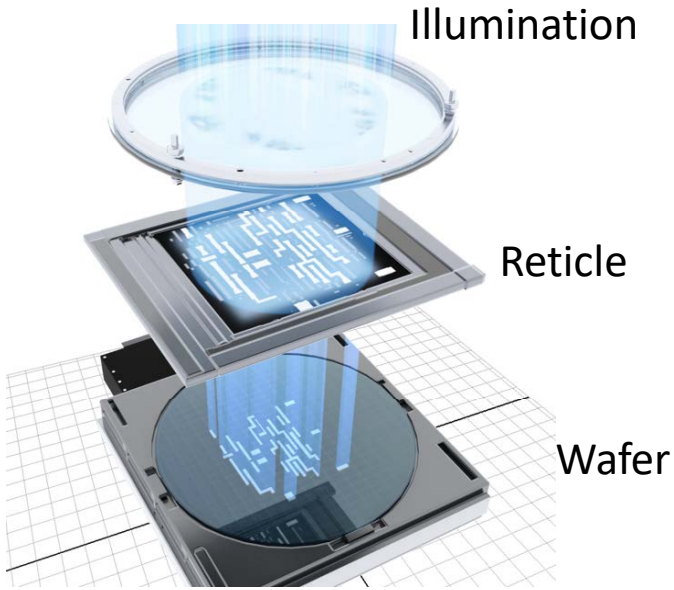
(Alignment & Level Sensor)

Public

Optical Metrology & Computational Lithography

Yieldstar Optical Metrology

(Scatterometry sensor for Overlay Measurement)



Computational Lithography

(Optimization of Illumination and Reticle for optimal printing)

Thank you!

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Veldhoven

Public