EUVL Scanners Operational at Chipmakers

Skip Miller

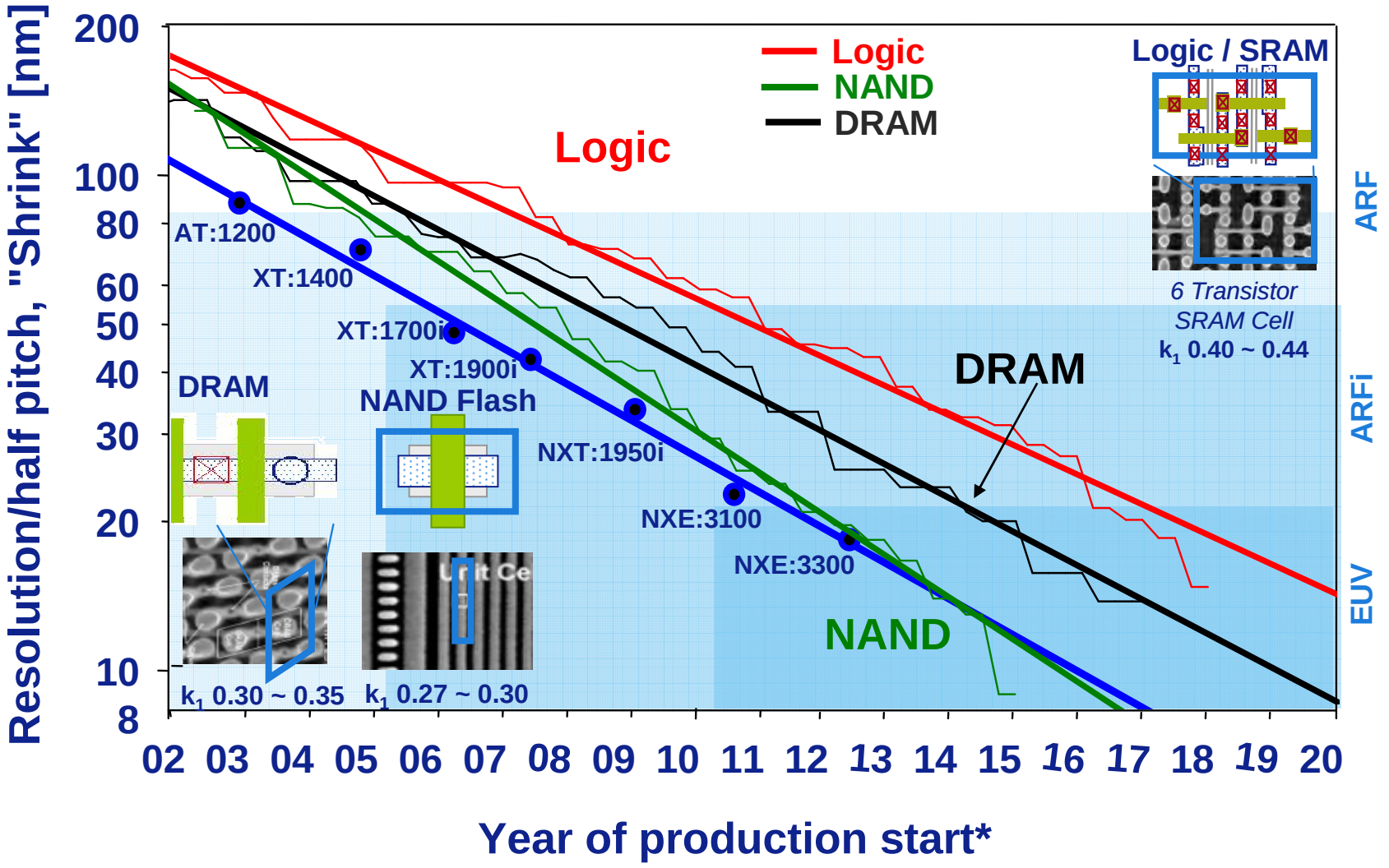
Semicon West 2011

Outline

- ASML’s Lithography roadmap to support Moore’s Law
- Progress on NXE:3100 (0.25NA) EUV systems
- Progress on NXE:3300 (0.33NA) EUV systems
- Summary

Industry roadmap towards < 10 nm resolution

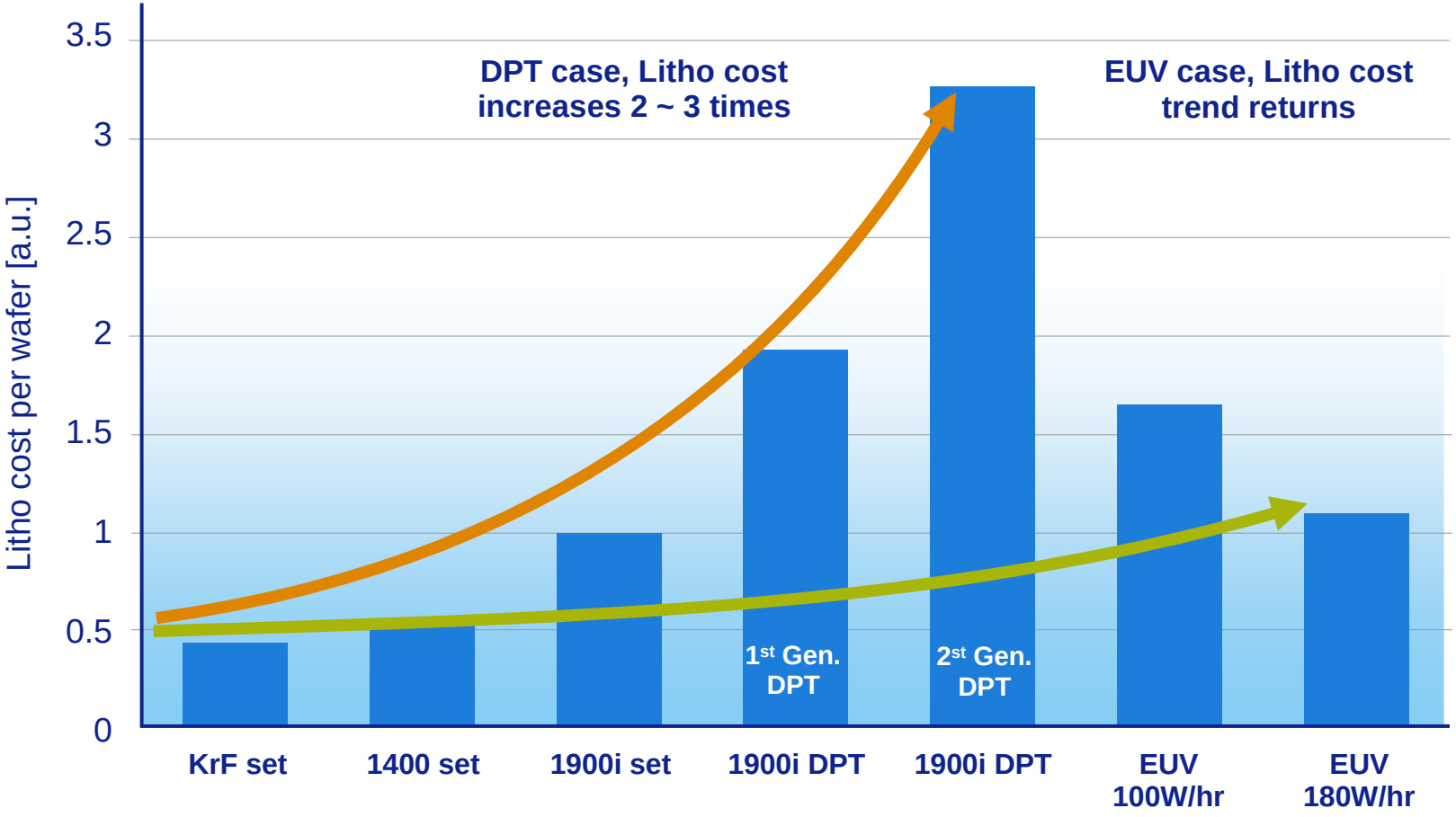
Lithography supports shrink roadmap



* Note: Process development
1.5 ~ 2 years in advance updated 2/11

ASML

Litho costs back to normal with EUV >100 W/hr



Source: Samsung, Prague, oct 2009

2 Alpha-demo tools used by multiple customers since 2006

imec

COLLEGE OF NANOSCALE SCIENCE & ENGINEERING
UNIVERSITY AT ALBANY State University of New York

	13.5 nm
NA	0.25
Field size	26 x 33 mm²
Magnification	4x reduction
Sigma	0.5

- 300mm Single stage
- linked to track
- Single reticle load
- Uses TWINSCAN technology
- Sn discharge source

SONY intel Micron hynix GLOBALFOUNDRIES Panasonic SAMSUNG SEMATECH ELPIDA TOSHIBA tsmc PSC Infineon IBM ASML

Public -Semicon We

ASML EUV Product Roadmap and Technology Status

NXE:3300 numerical aperture increased to 0.33

	2006 Proto System	2011 NXE:3100	2012 NXE:3300B	2013 NXE:3300C
Resolution	32 nm	27 nm	22 nm	18/16* nm
NA / σ	0.25 / 0.5	0.25 / 0.8	0.33 / 0.2-0.9	0.33 / OAI
Overlay (DCO/MMO)	< 7 nm	< 4/7 nm	< 3/5 nm	< 2.5/4.5 nm
Throughput W/hr	4 W/hr	60 W/hr	125 W/hr	150 W/hr
Dose, Source	5 mJ/cm^2, ~8 W	10 mJ/cm^2, >100 W	15 mJ/cm^2, >250 W	15 mJ/cm^2, >350 W

Main improvements

1) New EUV platform: N

2) Improved low flare op

3) New high sigma illum

4) New high power source

5) Dual stages

- ***Imaging 22nm demonstrated***
- ***Overlay <4/7nm shown***
- ***Productivity improvement plan in place to achieve 60W/hr***

- ***Building of frames and optics has started***

optional

4) Source power increase

5) Reduced footprint

enhancements

illumination

2) Source power increase

* Requires <7 nm resist diffusion length

ASML

Outline

- ASML’s Lithography roadmap to support Moore’s Law
- Progress on NXE:3100 (0.25NA) EUV systems
- Progress on NXE: 3300 (0.33NA) EUV systems
- Summary

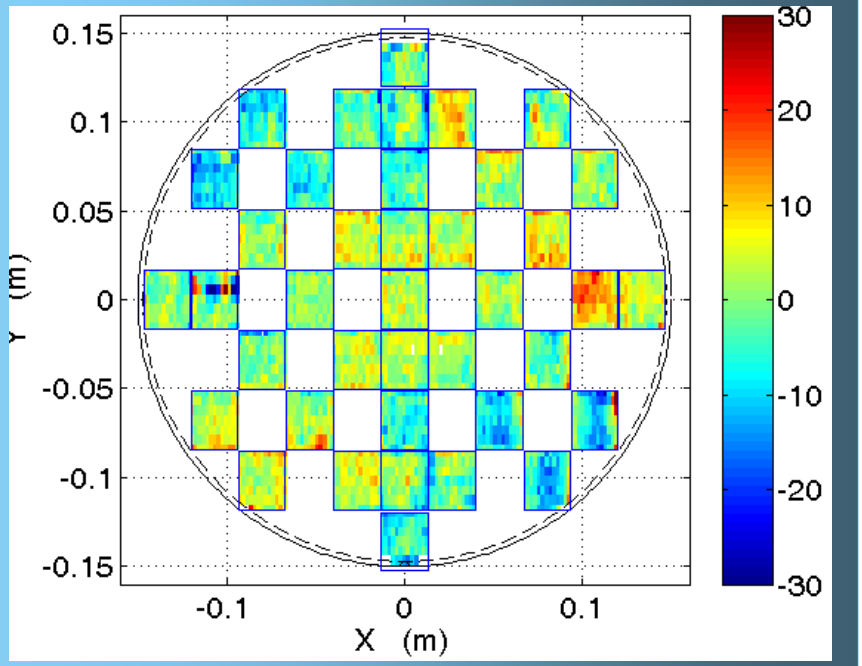
2011: EUV is moving ahead

- *NXE:3100 is*
  - *Exposing wafers at customer 1*
  - *Exposed wafers at customer 2*
  - *Exposing wafers at customer 3*
  - *Under installation at customer 4*
  - *Shipping to customer 5*
  - *In setup for shipment to customer 6*

NXE:3100 targets:

- Imaging
  - Resolution 27nm
  - NA=0.25
  - =0.8
- Overlay
  - DCO=4.0 nm
  - MMO=7.0 nm
- Productivity
  - 60wph
  - 10mJ/cm^2 resist

Focus and dynamics performance support good imaging performance



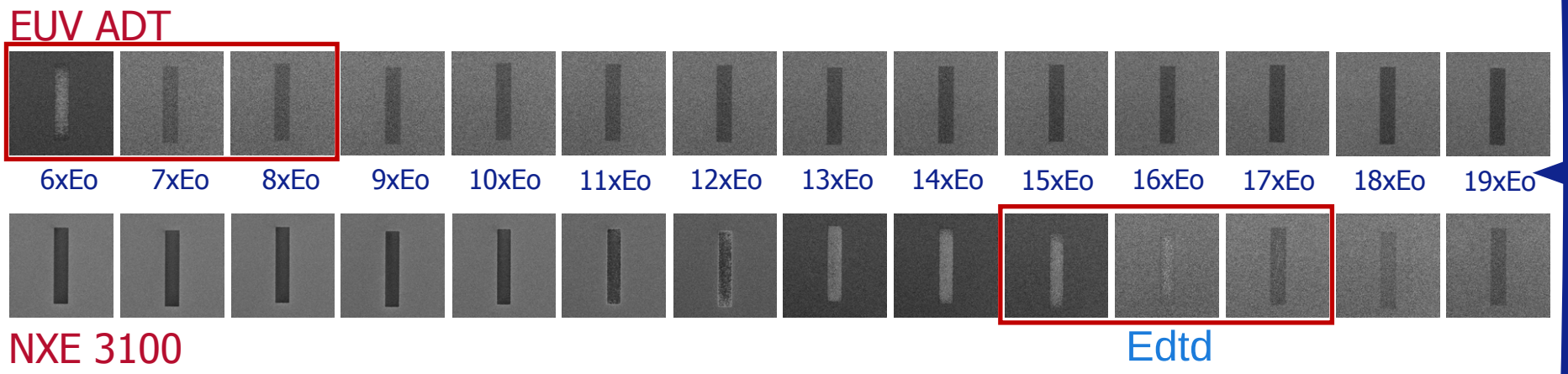
Focus Uniformity *22.3nm*

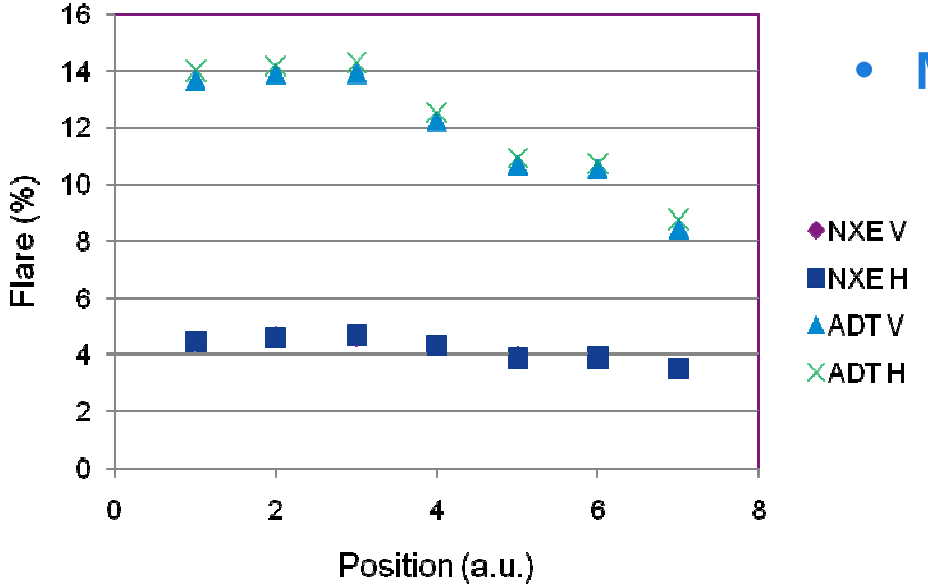
	Measured	Target
MA-X [nm]	0.32	0.60
MA-Y [nm]	0.24	0.60
MA-Z [nm]	1.12	6.0
MSD-X [nm]	2.91	3.2
MSD-Y [nm]	1.53	3.2
MSD-Z [nm]	6.9	21

System dynamics qualified at 60 W/hr conditions

Same wafer metrology will be used in NXE:3300

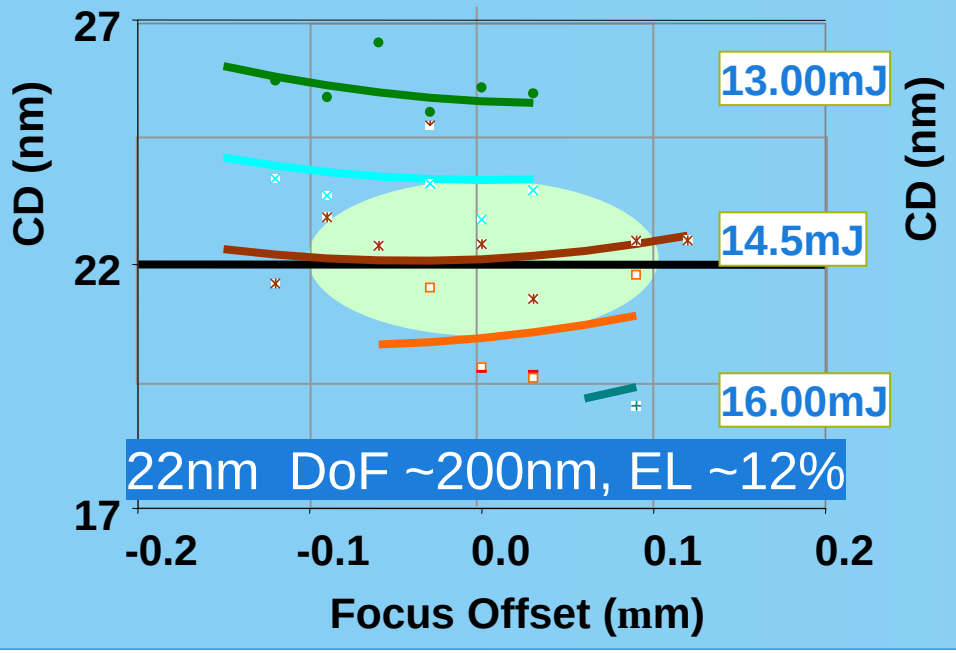
NXE:3100 flare measurement in resist confirms optical measurements of <5%

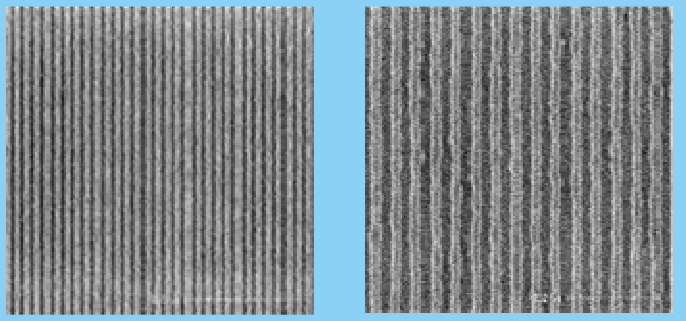




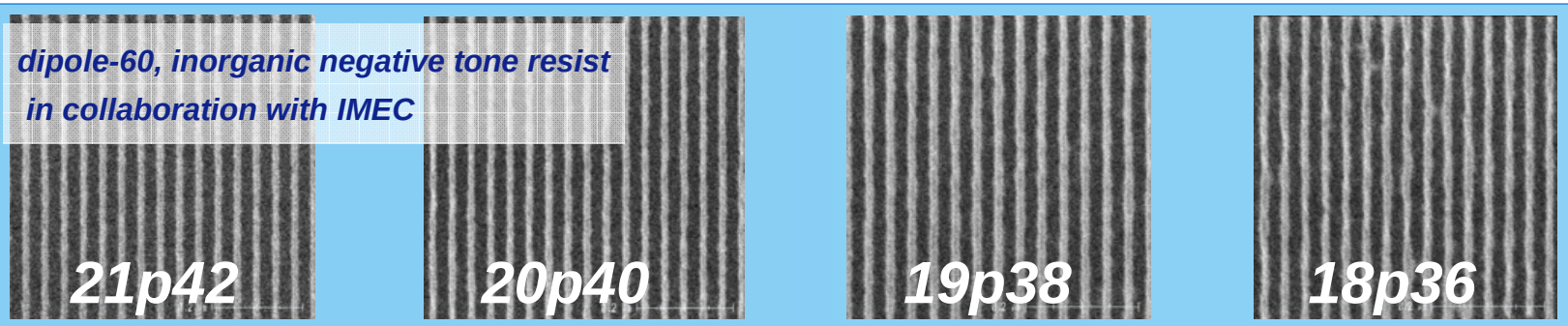
- **Methodology:**
  - **Dose to clear resist in open frame: Eo**
  - **Dose to disappear the pattern Edtd**
  - **Flare = Eo/Edtd- mask flare**

Large process windows for 22nm
Resolution extension to 18nm on NXE:3100



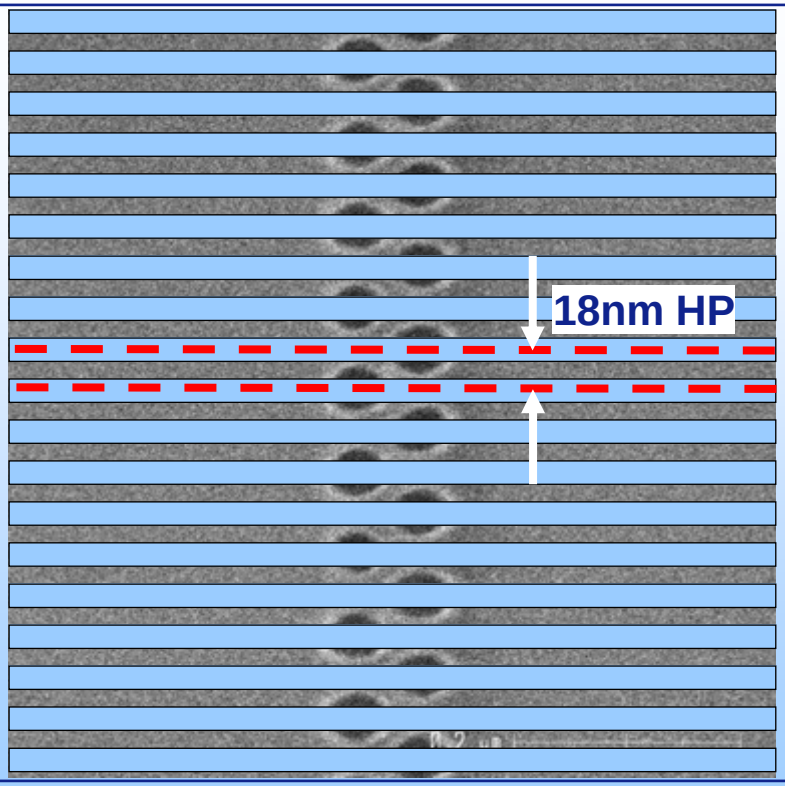
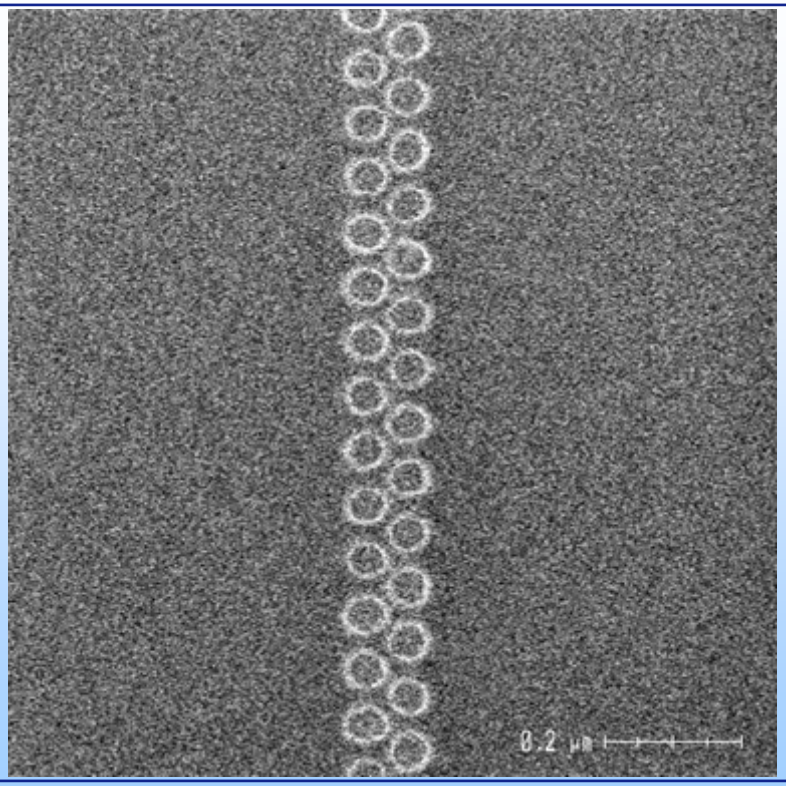


NA=0.25, 75deg dipole,
Resist dose ~15mJ/cm2
SEVR140 SB/PEB : 105°C/95°C



ASML

18nm Flash staggered contact layer well resolved

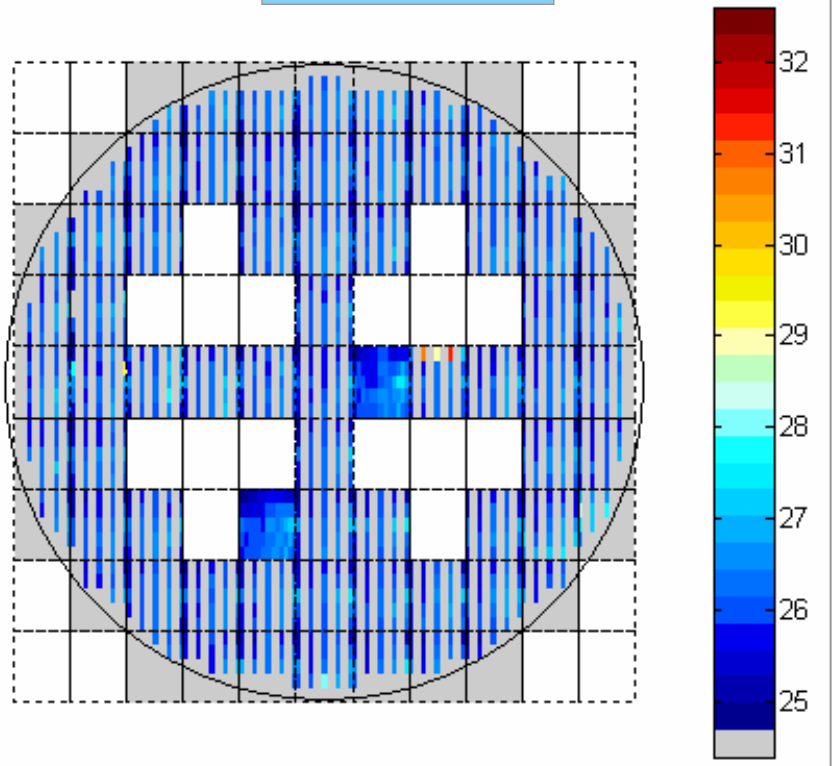
18nm node Flash CHs – 1.5x3f	20nm node Flash CHs – 1.5x2f
	
Bitline pitch = 36nm CH pitch = 65nm	Bitline pitch = 40nm CH pitch = 72nm

50nm SPUR-V002 on 20nm UL, TBAH develop + FIRM Extreme rinse
Dose = 20.0 mJ/cm²

ASML

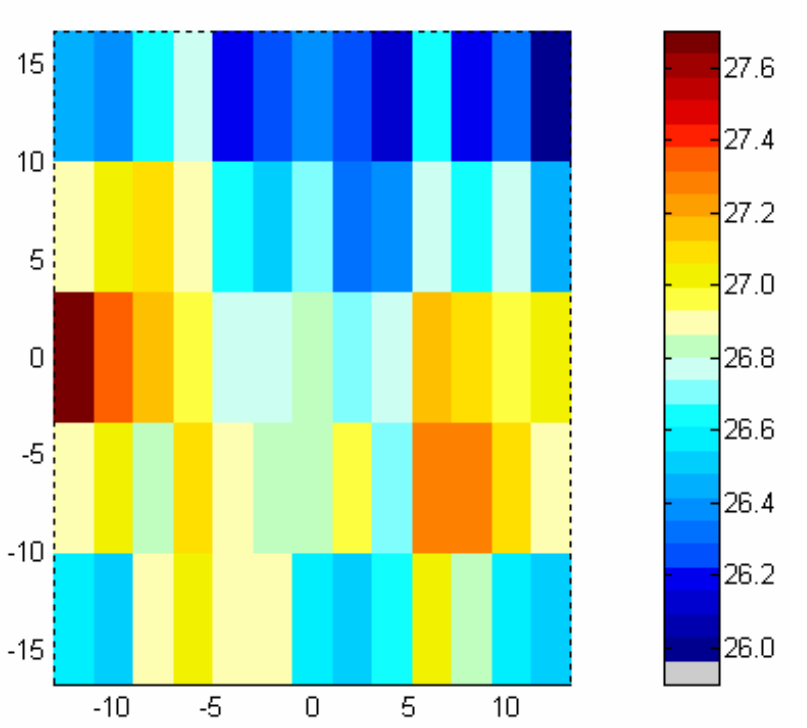
CDU full wafer and intrafield performance

Full wafer



Mean CD = 26.09
3 σ = 1.5nm

Intrafield

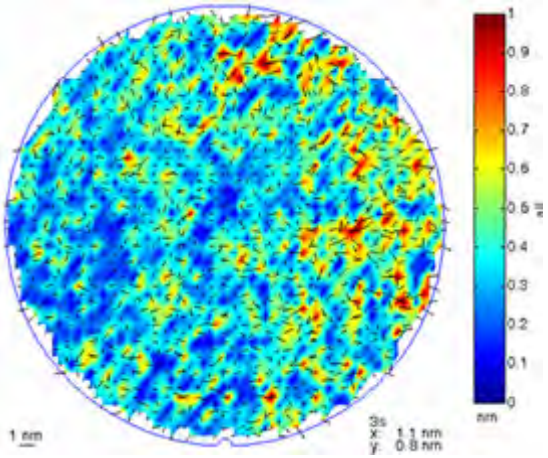


Mean CD = 26.7
3 σ = 1.0nm

Process - 50nm SPUR-V002 : Developer – TMAH +DIW Rinse : Dose 12mJ/cm²

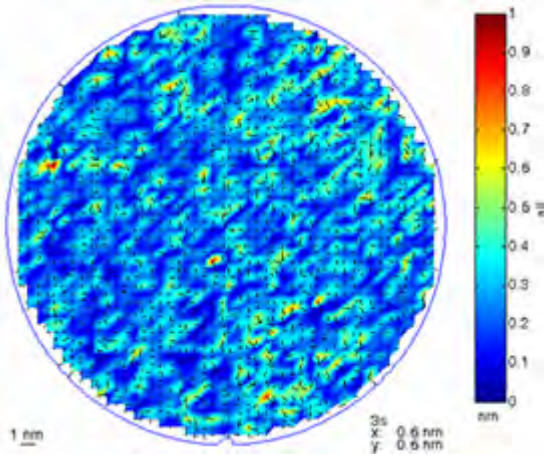
Improved Alignment Repro in Vacuum

Interferometers in air



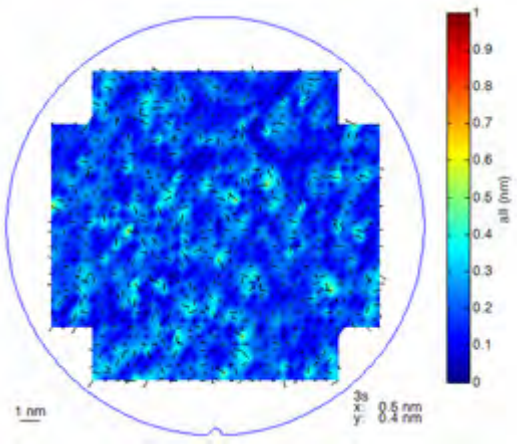
XT
Alignment repro
(1.1nm, 0.8nm)

Grid plate



NXT
Alignment repro
(0.6nm, 0.6nm)

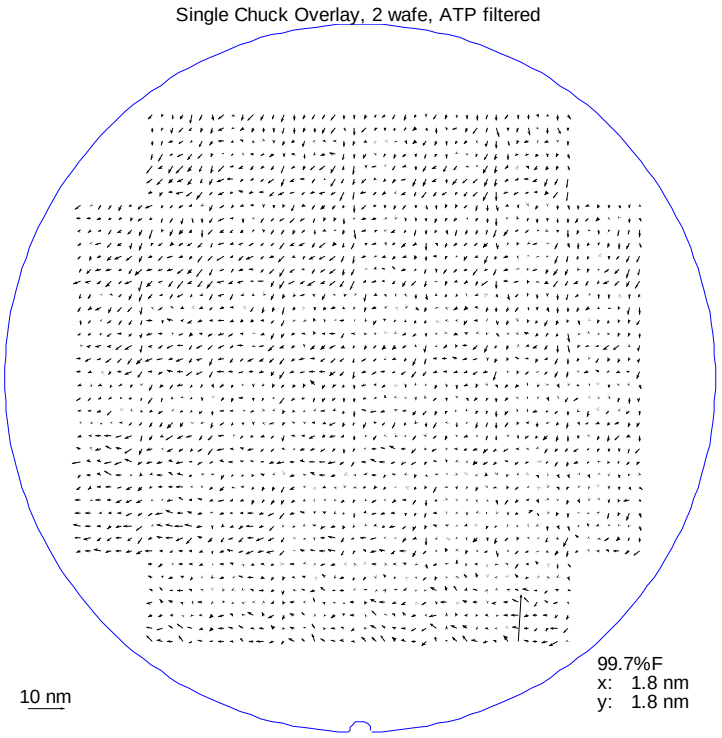
Interferometers in vacuum



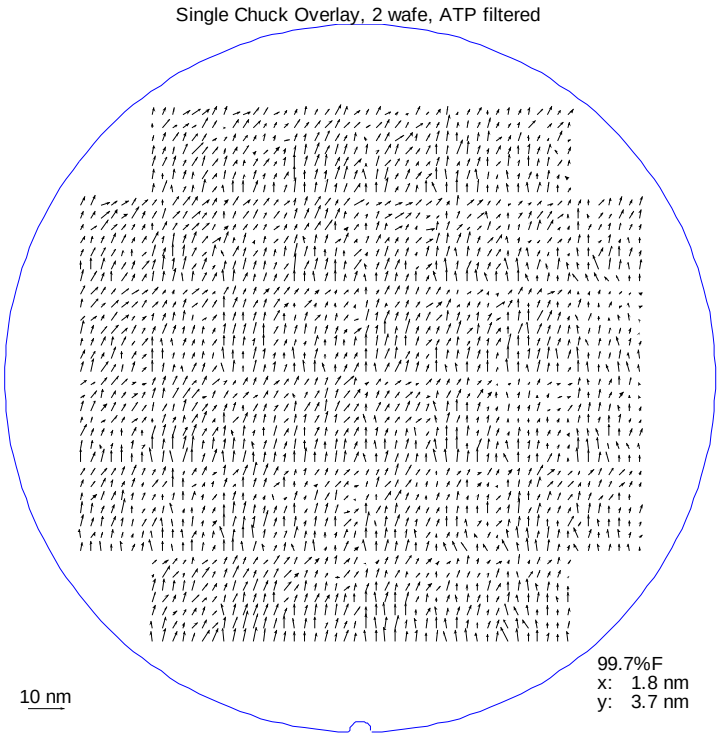
NXE
Alignment repro
(0.5nm, 0.4nm)

Dedicated chuck Overlay <4nm

Champion data <2nm



(x:1.8,y:1.8)

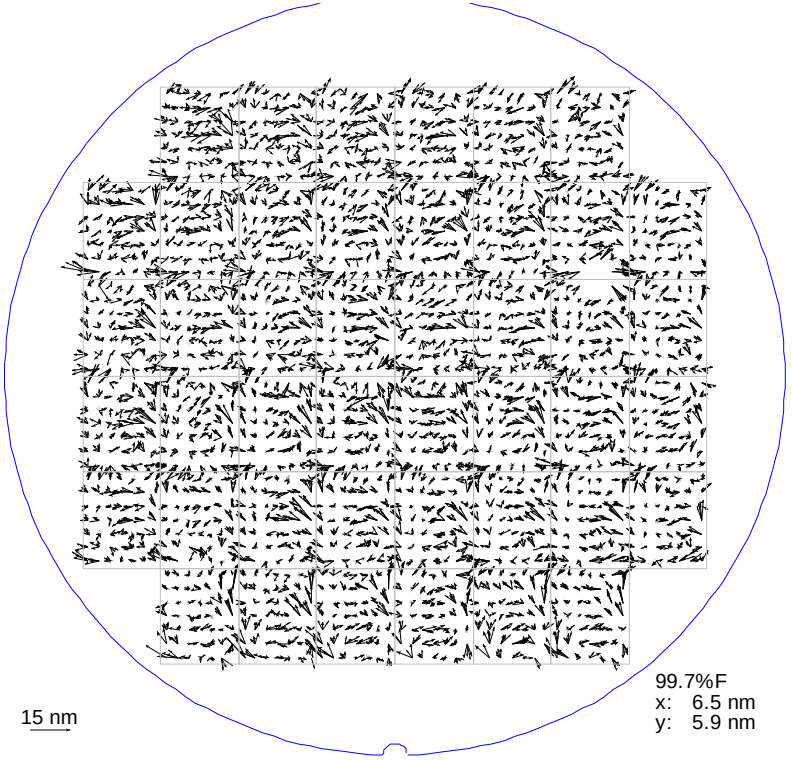


(x:1.8,y:3.7)

2 wafer lot after standard system calibration, 44 fields, 99.7%

EUV-to-ArF Overlay measured at 6.5 nm

Matched Machine: EUV to ArF



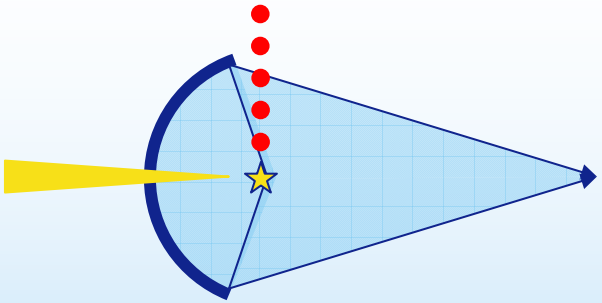
4 wafers: (x:6.5,y:5.9)

ArF: XT:1450, Standard system calibration, 44 fields, 99.7%

2 EUV source concepts integrated and exposing

Criticality of source supply requires ASML to seek multiple suppliers

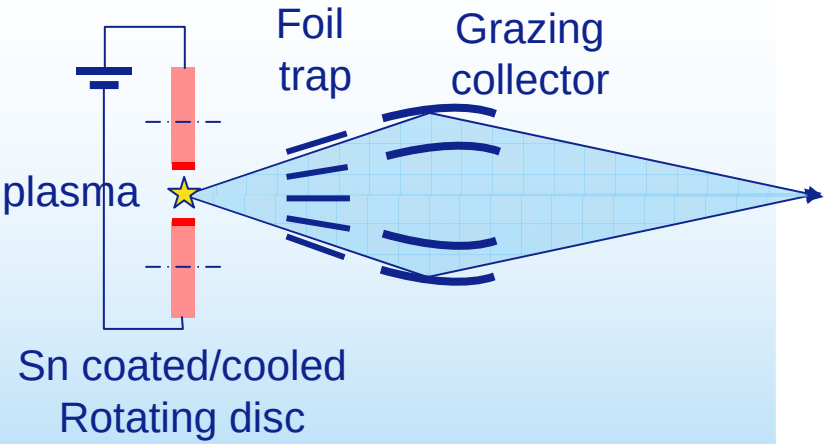
Laser-Produced Plasma (LPP)



- CO_2 laser ignites tin plasma
- Debris mitigation by background gas and possible magnetic field (Komatsu)

Suppliers Cymer, Gigaphoton

Laser Assisted Discharge (LDP)



- High voltage ignites tin plasma
- Debris mitigation by rotating foil trap

Supplier: XTREME (Ushio)

Light source suppliers progressing toward NXE:3100 throughput target of 60 wafers per hour

CYMER

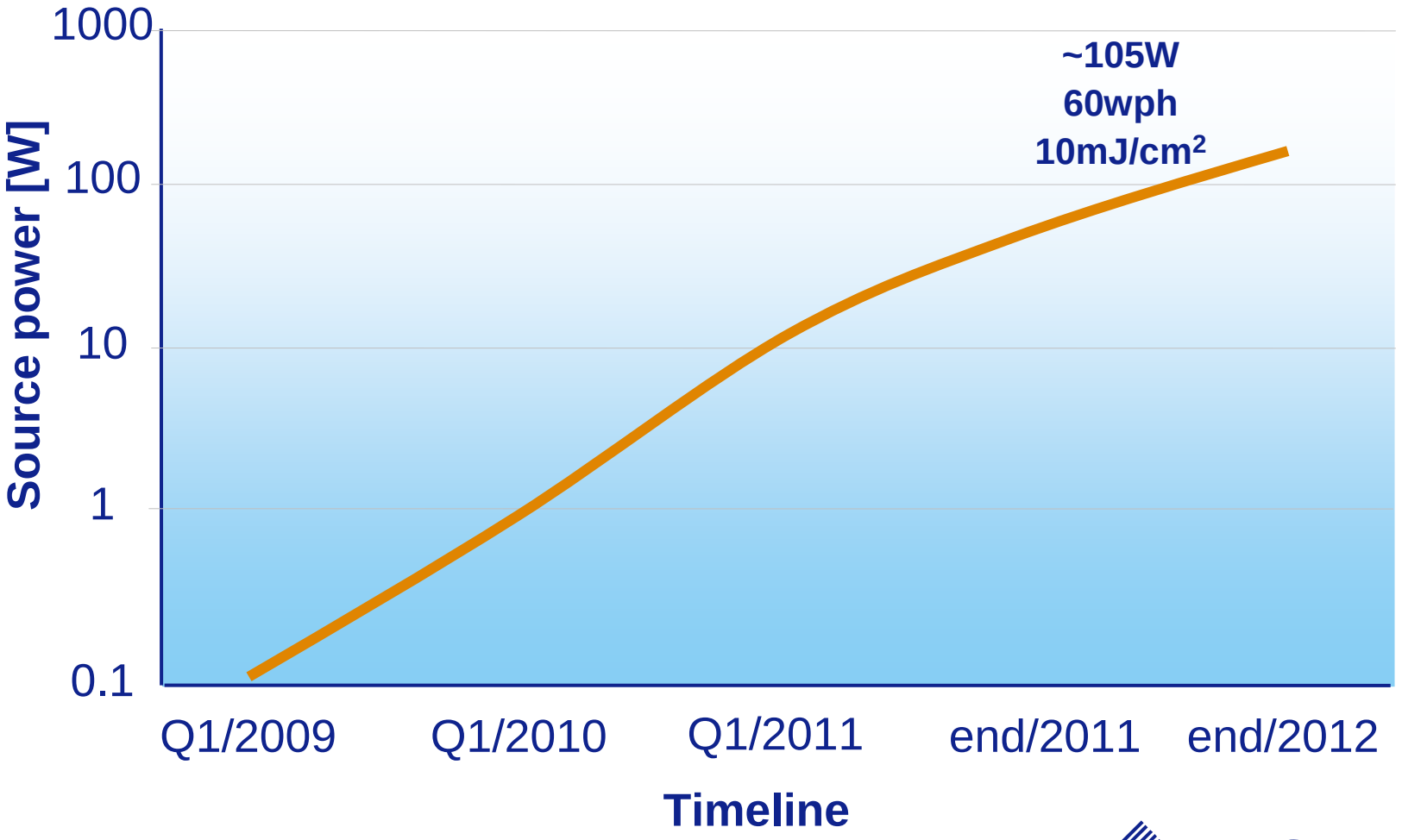
XTREME technologies

- Removed picture for handout

- Removed picture for handout

Source power progress 10x per year

however final leap to 100 W equivalent with 60 W/hr still a challenge



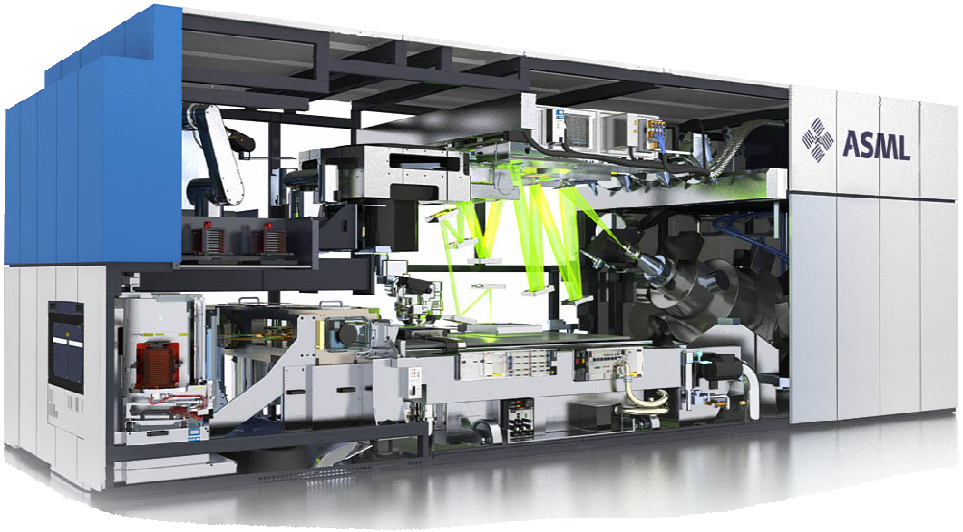
ASML

Outline

- ASML’s Lithography roadmap to support Moore’s Law
- Progress on NXE:3100 (0.25NA) EUV systems
- Progress on NXE: 3300 (0.33NA) EUV systems
- Outlook

NXE:3300 – building on the 3100

- NXE:3300 is a continuation of the 3100 platform, with a changed optical column and reduced footprint to enable
  - Improved resolution (0.33NA), capability for off-axis illumination without energy loss, higher productivity at higher dose.
  - Improved cost of ownership
- Stages, handlers, software, sensors will be taken over as much as possible from 3100 for 3300

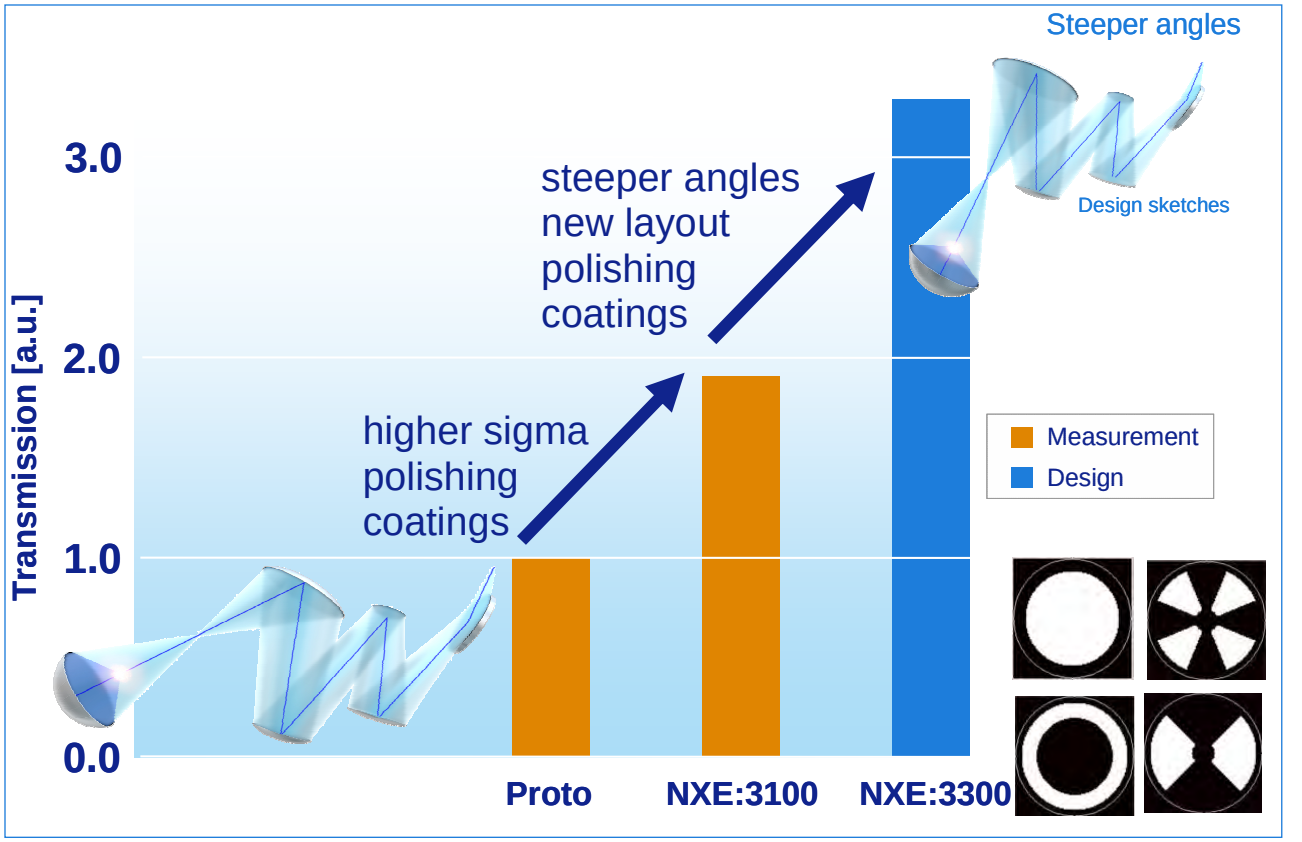


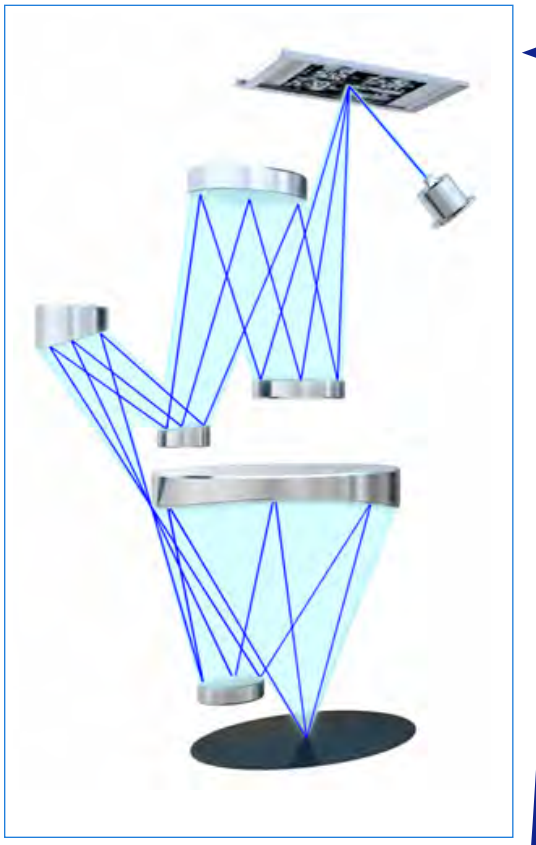
System performance	NXE:3300B
NA	0.33
Resolution (half-pitch)	22 nm (18 nm with OAI)
Overlay (DCO / MMO)	3.0 / 5.0 nm
Throughput	125 wph @ 15 mJ/cm^2

System Transmission significantly improved

- Flexible Off-Axis illumination

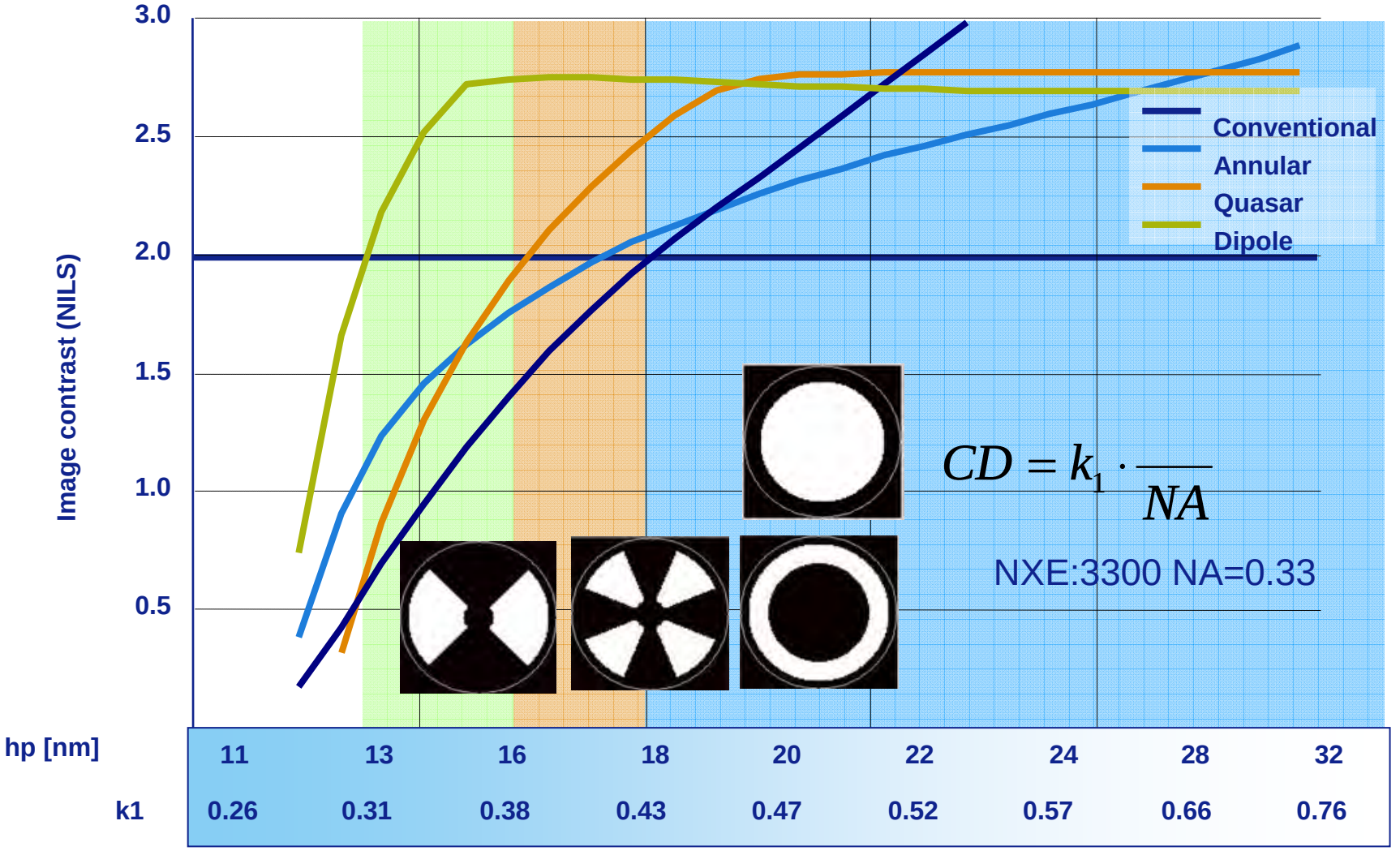
- Six mirror lens extension from NXE:3100





Further resolution extension with off-axis illumination

Dipole illumination extends resolution below 16 nm



ASML

Main frames for NXE:3300 are in production

First frames delivered to ASML

Milling WS metroframe ongoing

Removed pictures for handout

Pre milling MID support frame ongoing

NXE:3300 Hardware realization towards integration phase

Reticle Handler

Top cluster

- RS and RH integrated
- RS Dynamics qualified at 60 wph
- RS Functional testing ongoing towards 100wph

Removed pictures for handout

Mid-frame

Pre-qual. illuminator

Pre-qual. optics: enables early integration of (dynamics) functionality prior to sharp optics delivery

Mid cluster

- Delivered to ASML

Bottom-frame

Bottom cluster

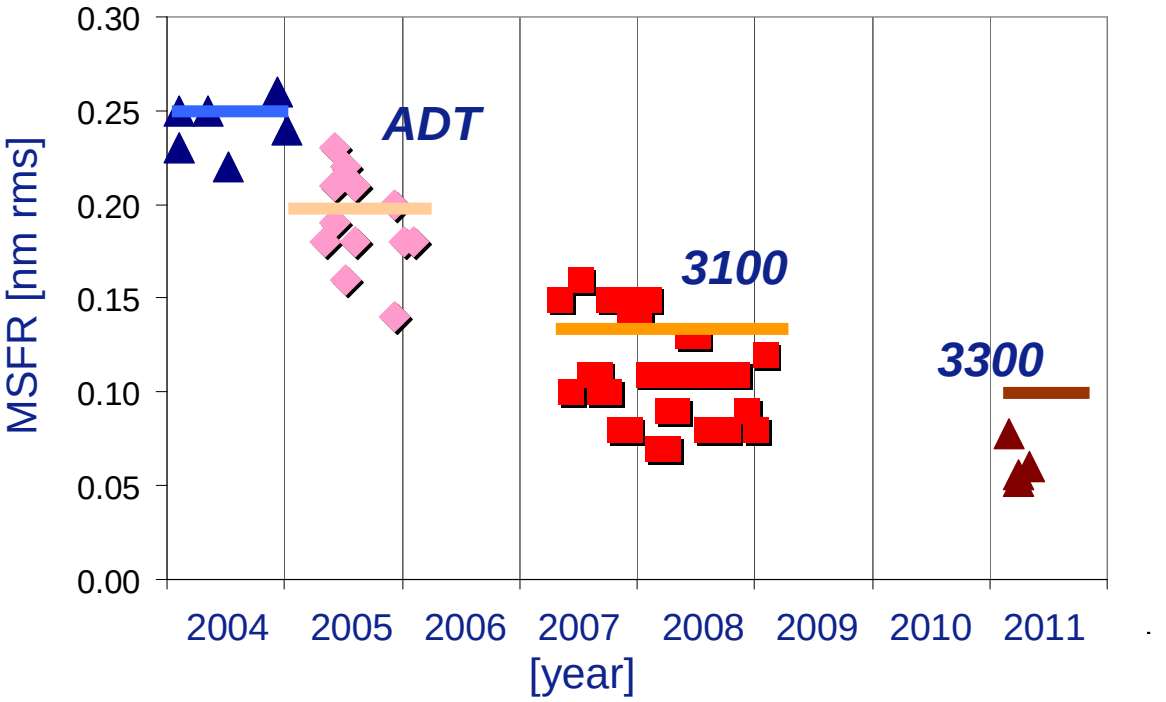
- Bottom-frame in milling phase
- Delivered to ASML July'11
- WS, WH delivery July''11

NXE:3300 – material for 12 optics sets in production loop – now >40 lens mirrors in optical polishing

Removed picture for handout

courtesy of Zeiss SMT AG

NXE:3300 – first mirrors in flare specification



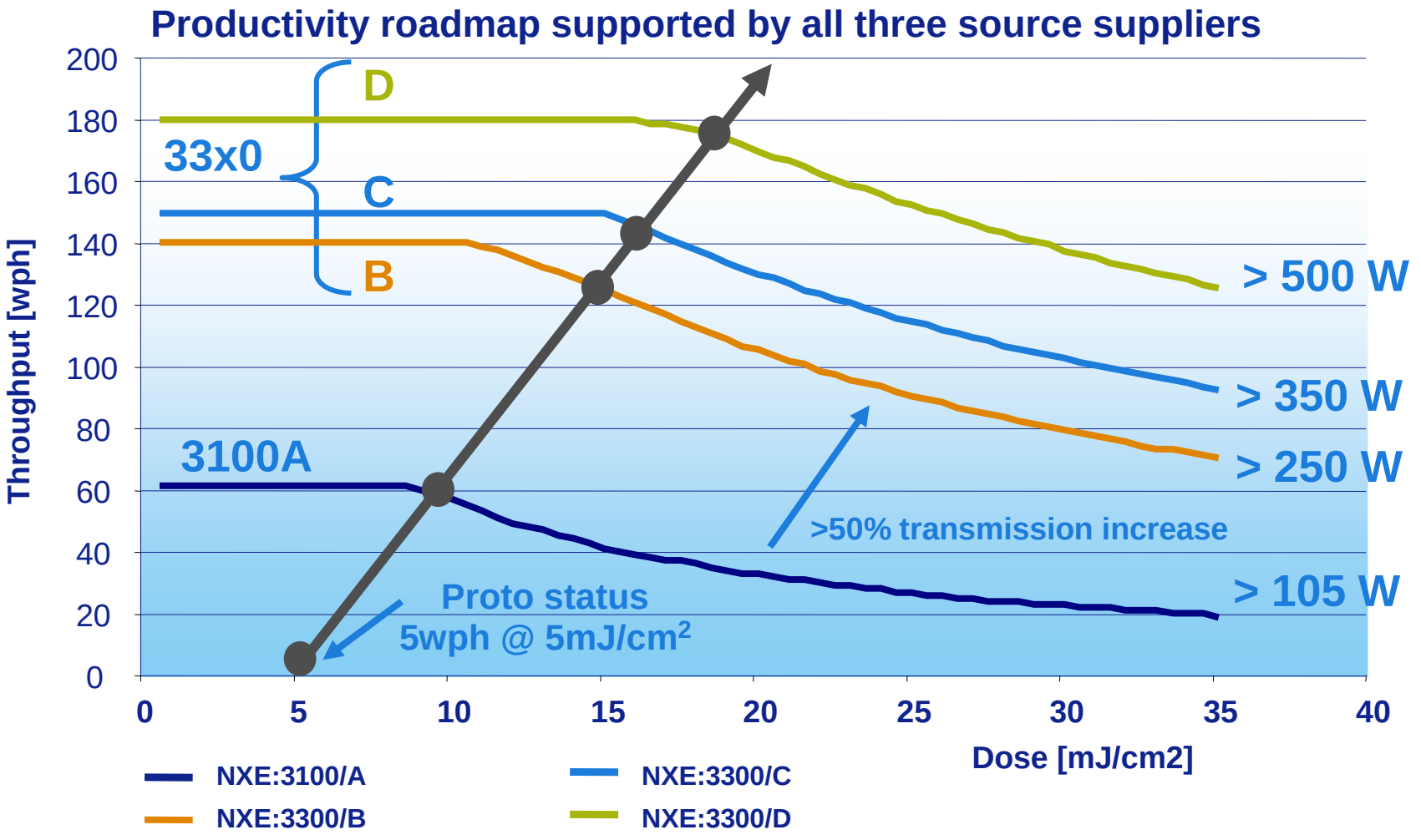
Removed picture for handout

First result on 3300 mirror verify the 6% flare specification and show potential down to 4% (below a 2µm line)

courtesy of Zeiss SMT AG

Source Power, Resist Sensitivity, Transmission, Stages

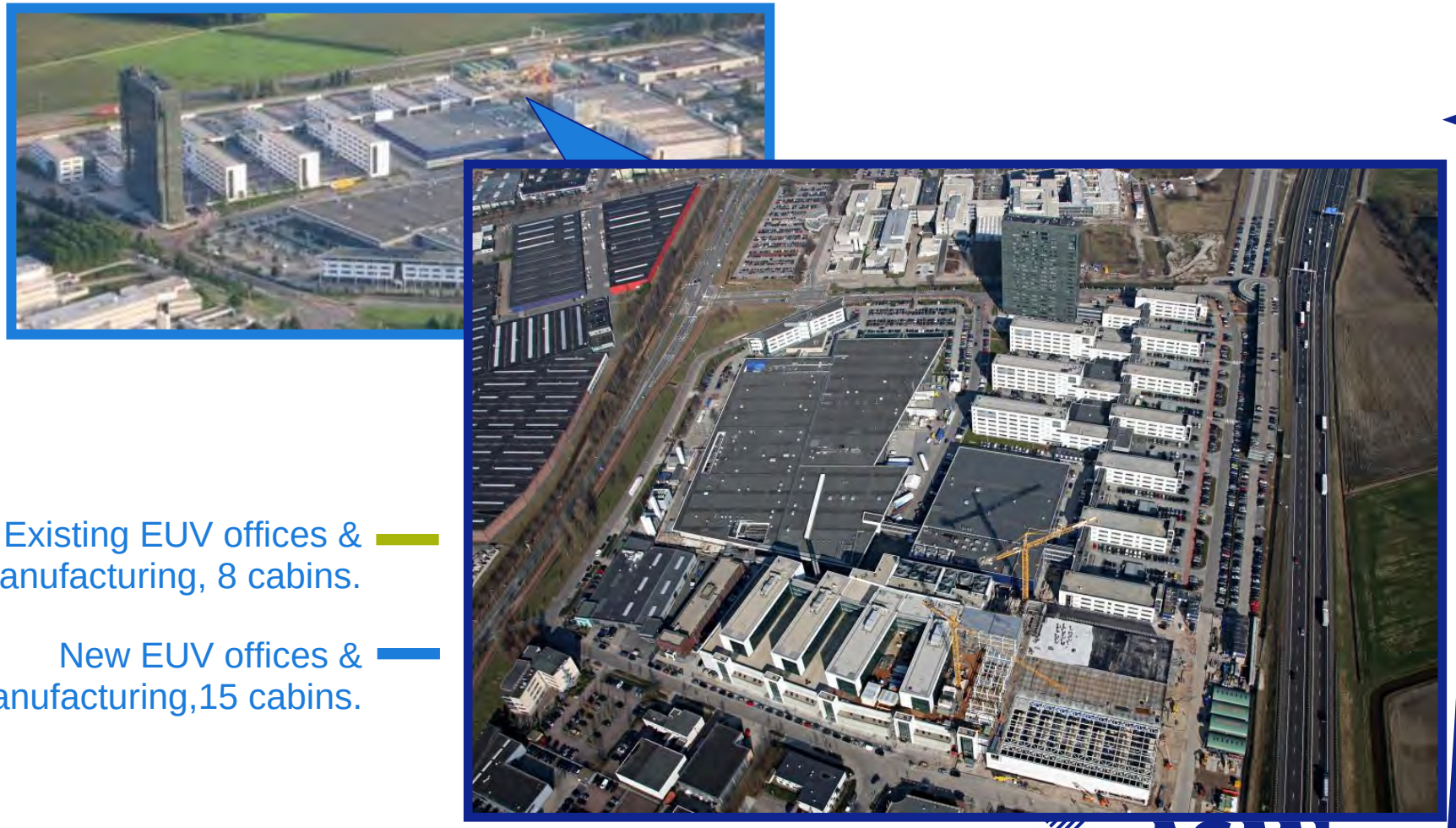
All need to increase over time to meet user cost targets



ASML

New EUV facilities planned to be available end 2011

NXE production capacity increases ~3x



Existing EUV offices & manufacturing, 8 cabins.

New EUV offices & manufacturing,15 cabins.

Outline

- ASML’s Lithography roadmap to support Moore’s Law
- Progress on NXE:3100 (0.25NA) EUV systems
- Progress on NXE: 3300 (0.33NA) EUV systems
- Summary

EUV is moving forward

- ASML has 4+ years of accumulated EUV field experience with 1st generation EUV tools at research institutes in Belgium and the US
- 2nd generation EUV NXE:3100 system shipments in progress, 4 systems shipped, 3 running wafers at customer production site, 1 under installation, 1 shipping, 1 remaining system to ship.
- 3th generation EUV tool NXE:3300 in development, module manufacturing in progress, capable of printing features down to 16 nm in volume manufacturing
- ASML has customer commitments for 10 NXE:3300 systems to be delivered starting in 2012
- Productivity roadmap remains major challenge although major progress continues to be made with 3 source suppliers
- To meet future EUV demand, construction on the new EUV factory extension has started

ASML