EUV Lithography
Towards Industrialization

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Dublin Meeting November 2014

Agenda

- EUV benefit and status at customers
- Towards higher productivity
- Summary

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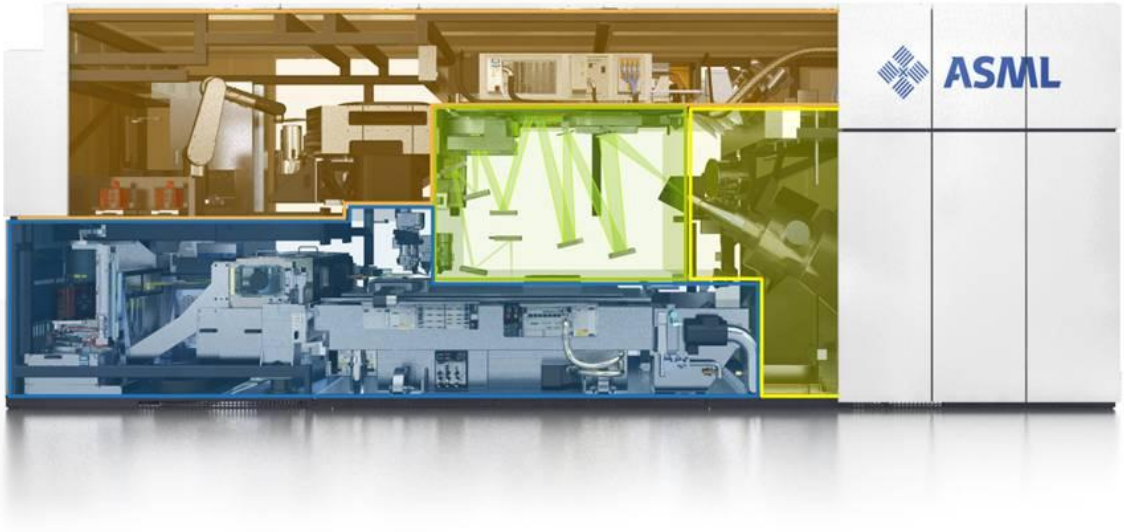
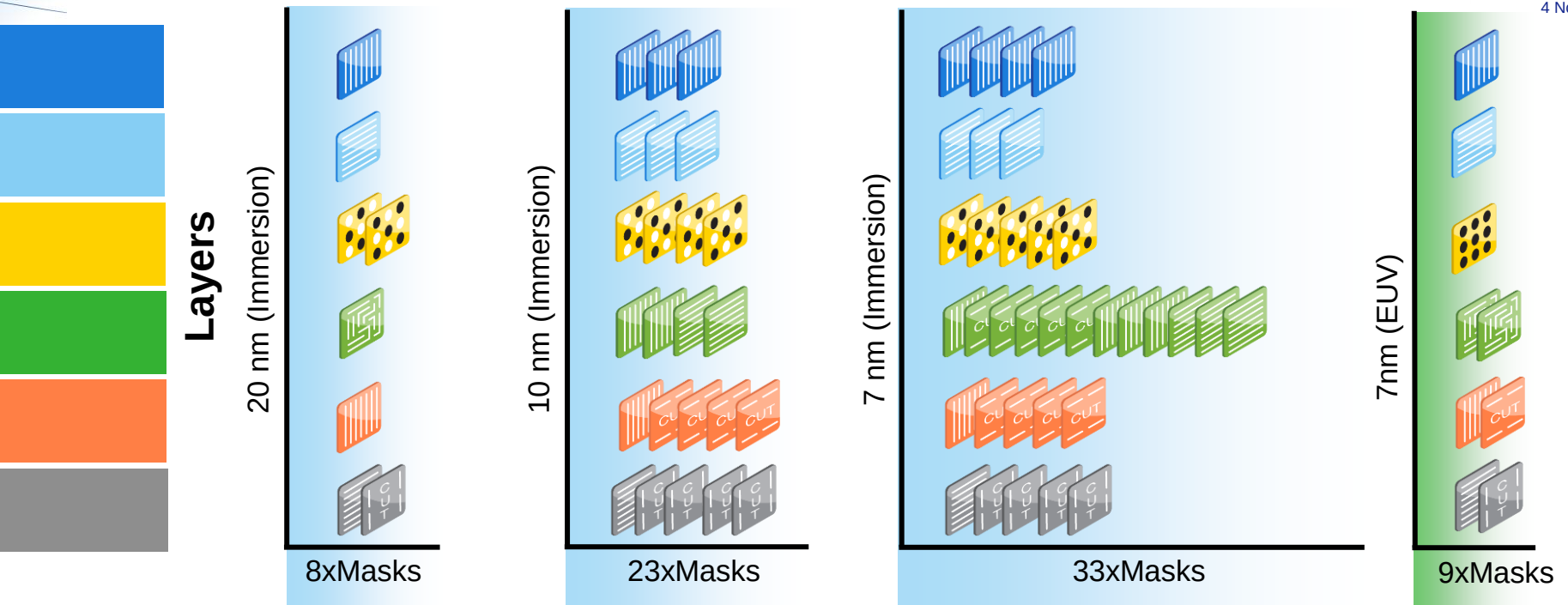
- **EUV benefit and status at customers**



Multi-patterning complexity drives need for EUV

EUV Lithography will stop the strong increase of litho steps/masks needed



Node	20 nm	10 nm	7 nm	7 nm
# of litho steps	8 (Immersion)	23 (Immersion)	33 (Immersion)	9 (EUV)
# OVL Metrology	9-11	36-40	59-65	12
# max metrology / litho steps	2	3	4	3

EUV status:
Demonstrated >500 wafers per day at customer sites

- More than 500 wafers exposed per day during endurance tests at 2 customer sites
- 7 NXE:3300B systems shipped to customers
- 4 more NXE:3300B systems being integrated
- 4th generation NXE system (NXE:3350B) integration ongoing
- EUV cleanroom extension is under construction

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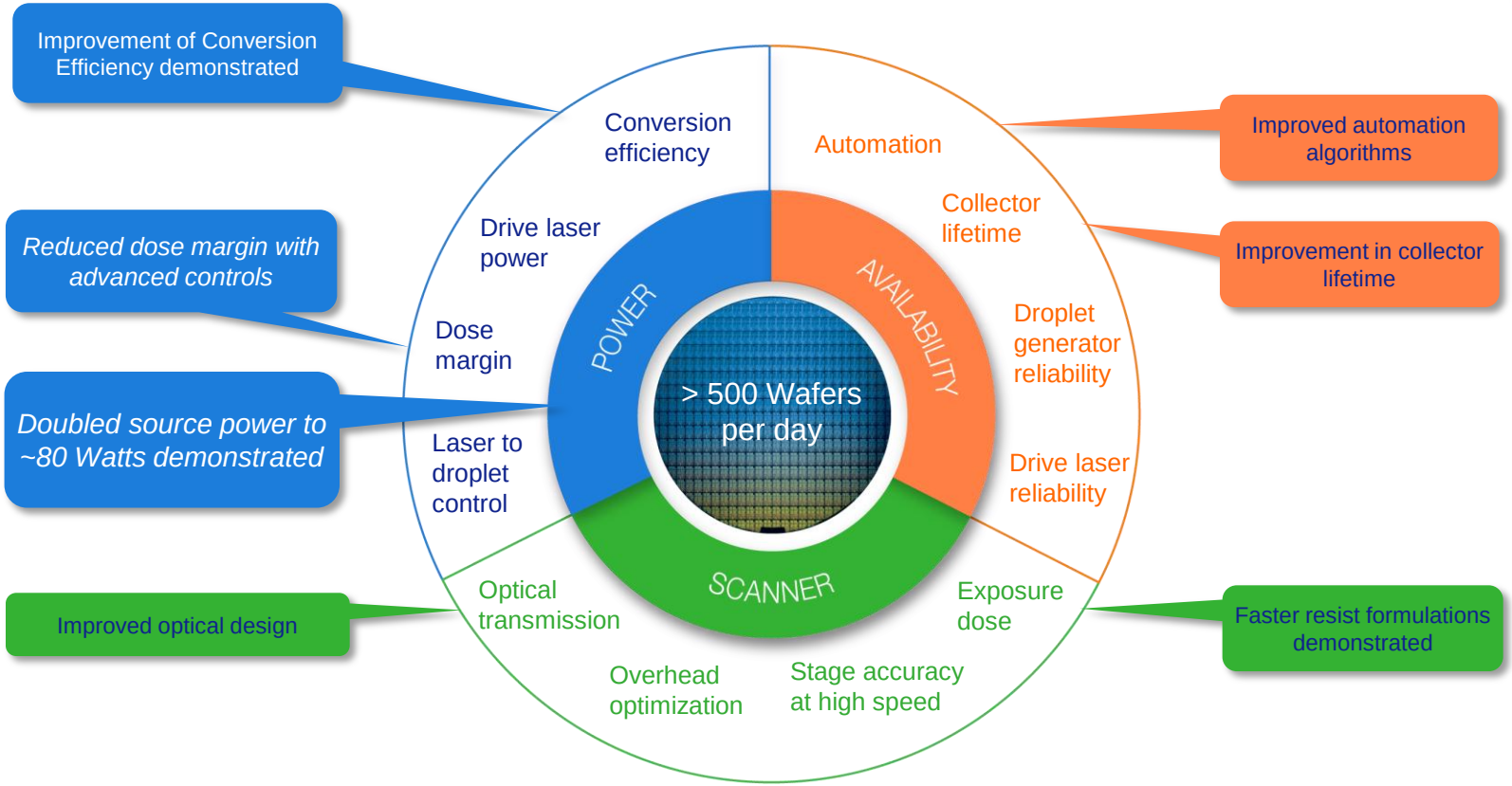
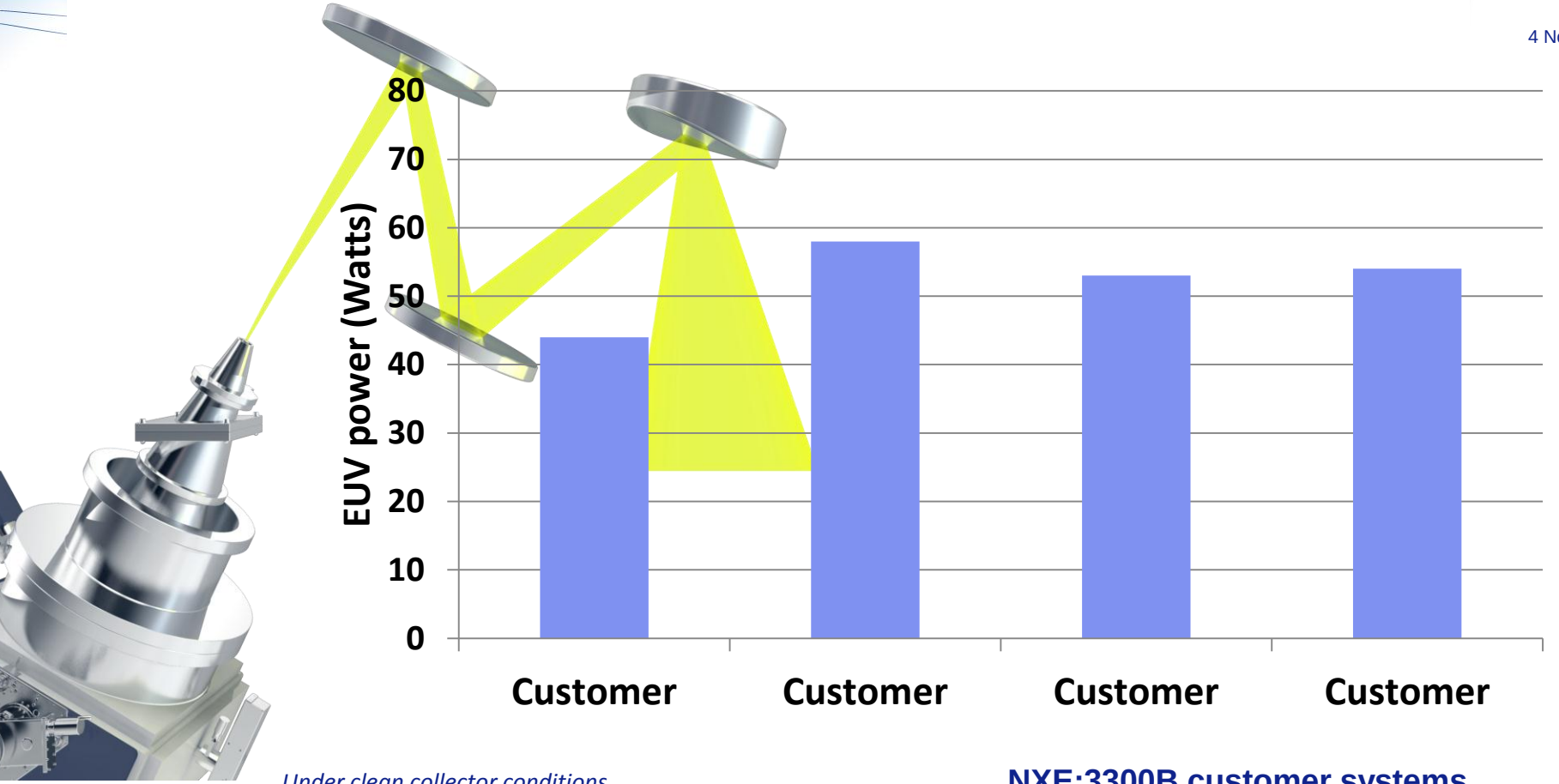
Wafers per day program: Progress in major areas



>40W rolled-out on customer NXE:3300B systems

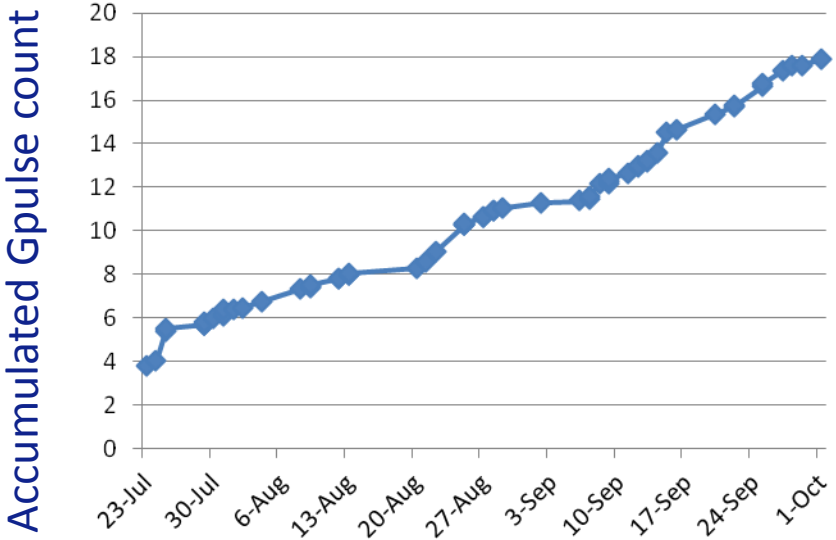


Under clean collector conditions

NXE:3300B customer systems

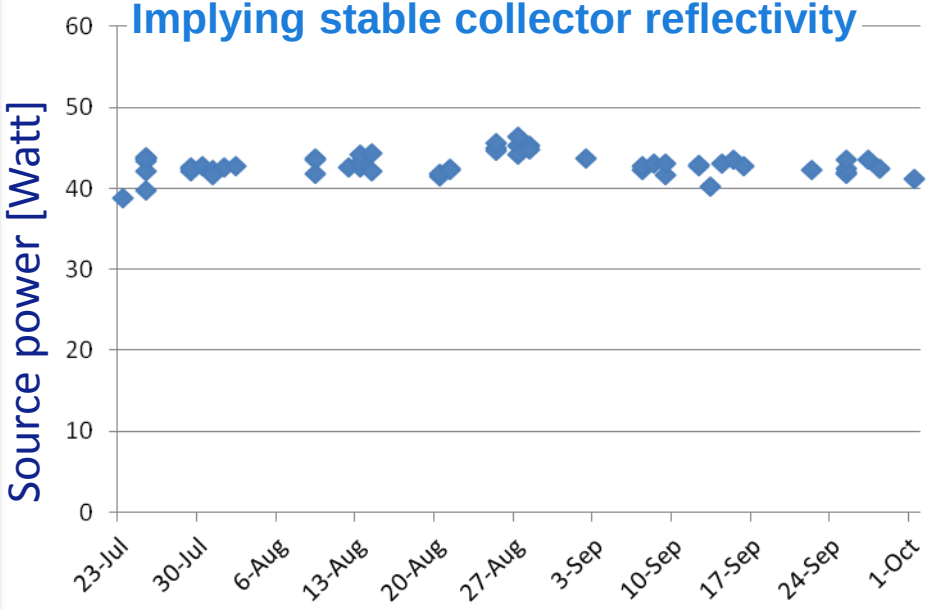
Customer system continuous use at power level of >40W

System pulse count



System continuously used

Power of >40W since start use system Implying stable collector reflectivity

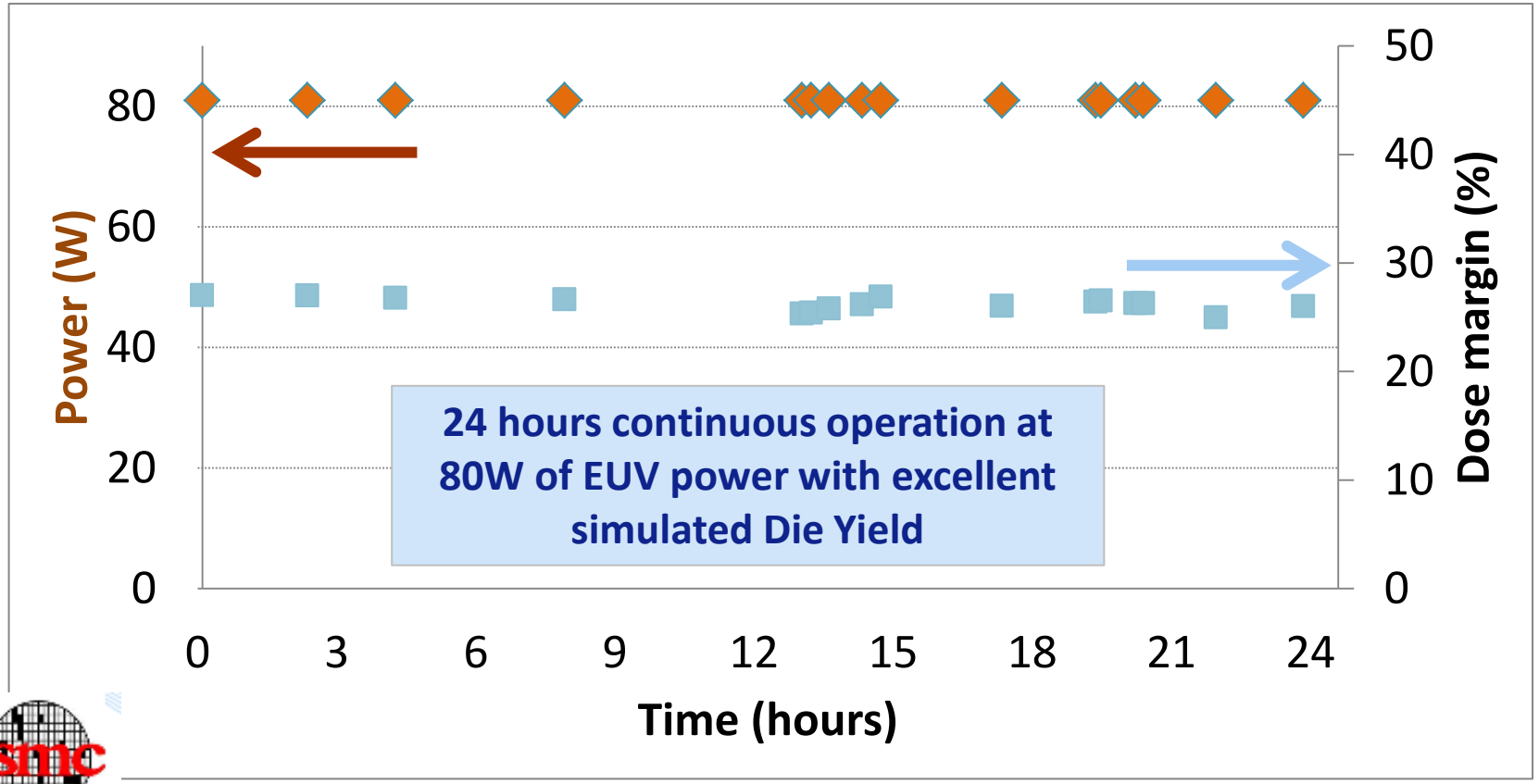


Stable power over 2 months period of time

Courtesy of IBM

Continuous stable source operation at 80 W

excellent die yield, ~25% dose margin



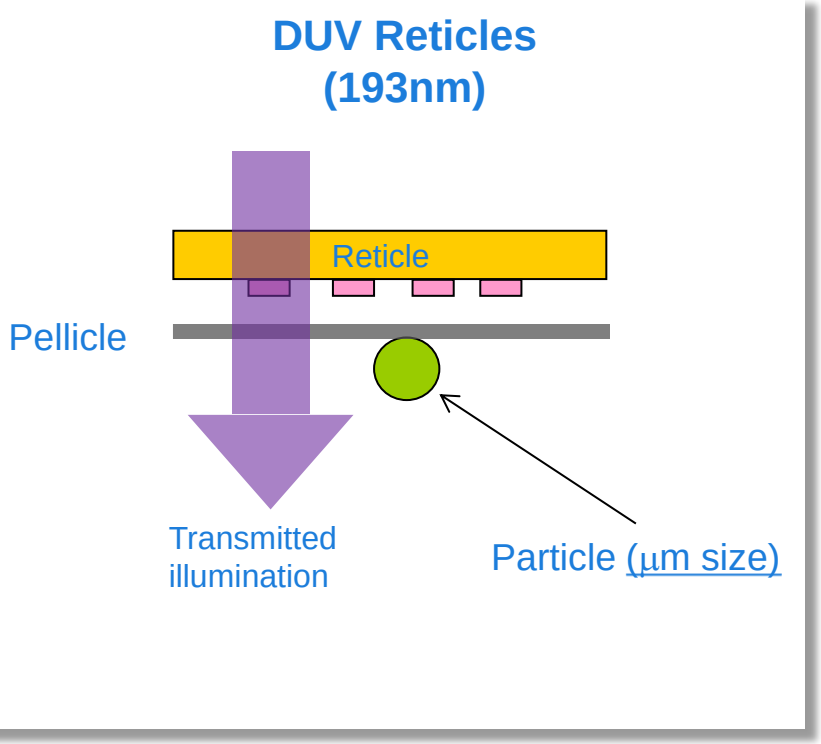
Die Yield = Simulated % of dies that meet the 1% dose requirement

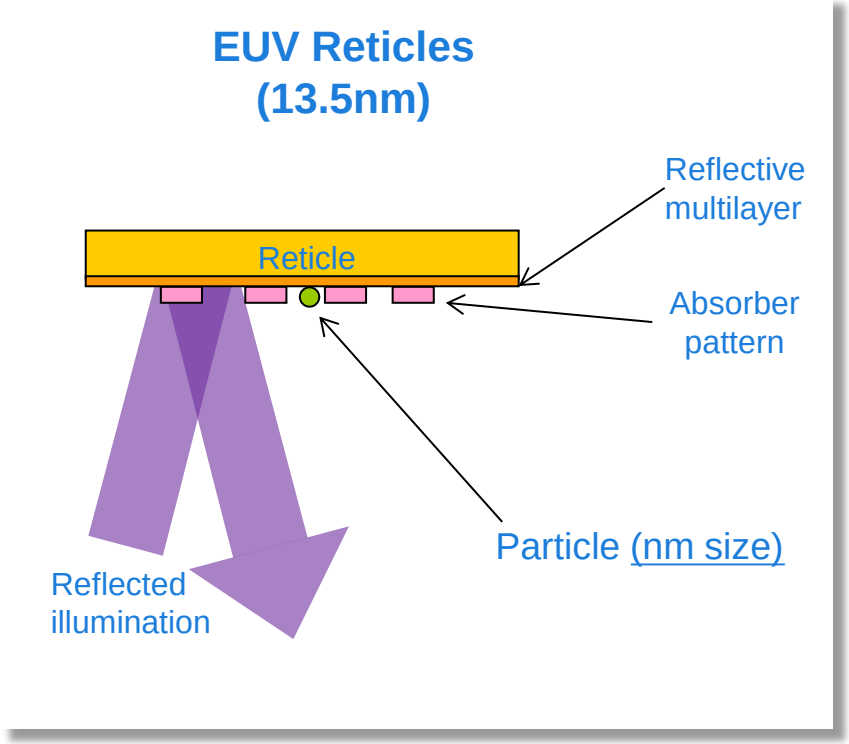
An Intermezzo

- Towards an pSi pellicle for EUV tools
- Source aspects

The mask defect challenge

Challenging defect requirements on reflective EUV mask without pellicle

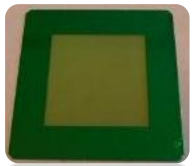


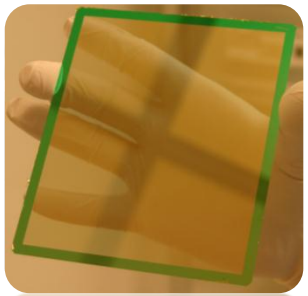


Scalability of free-standing pSi films demonstrated and prototype pSi pellicles successfully tested in EUV tools

Full size prototype

Half size prototype



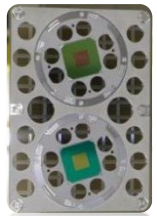


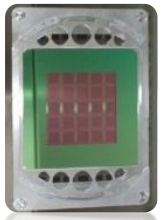
11mm x 11mm (~80% EUV transmission)

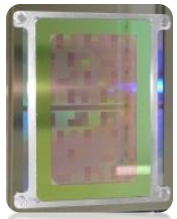
50mm x 50mm (~82% EUV transmission)

64mm x 106mm ~(86% EUV transmission)

103mm x 122mm (~85% EUV transmission)



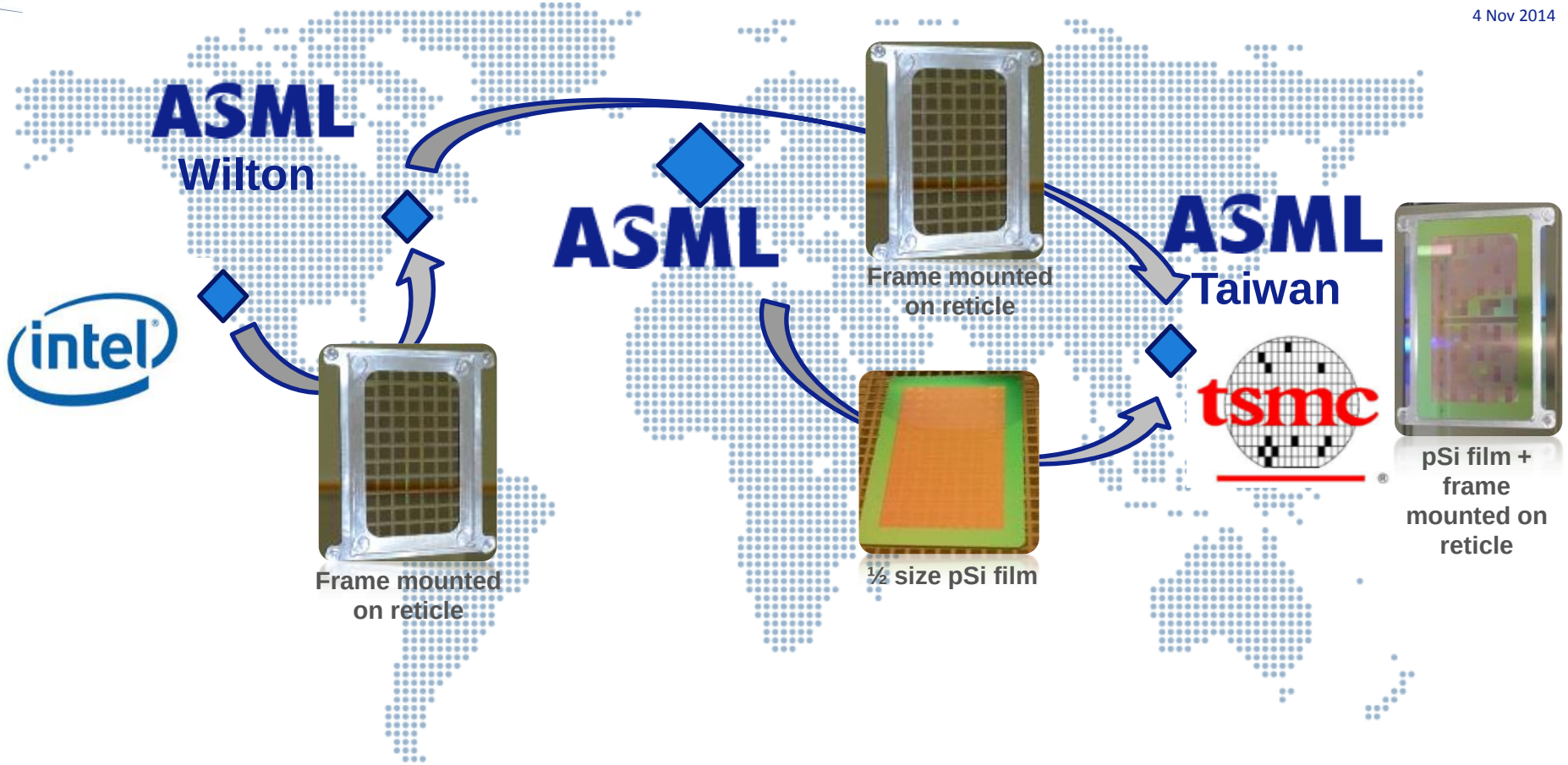




Open frames used for testing prototype pSi pellicles in EUV tools

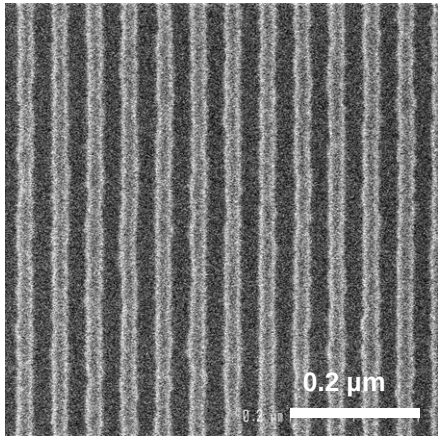
All reticles and frames courtesy of Intel

Imaging testing of ½ size pSi pellicle collaborative effort of ASML and customers



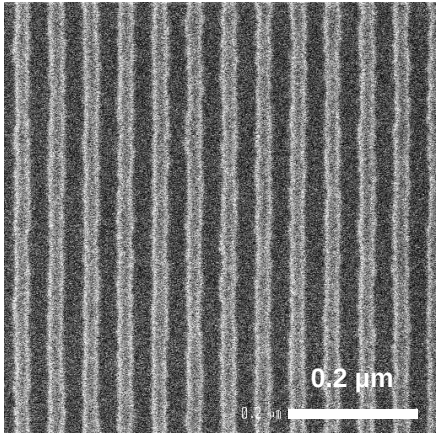
27 nm L/S features successfully exposed with half-size proto pellicle

SEM image at BE/BF
w/o pellicle



CD = 24.2 nm
LWR = 4.0 nm

SEM image at BE/BF
w/ pellicle

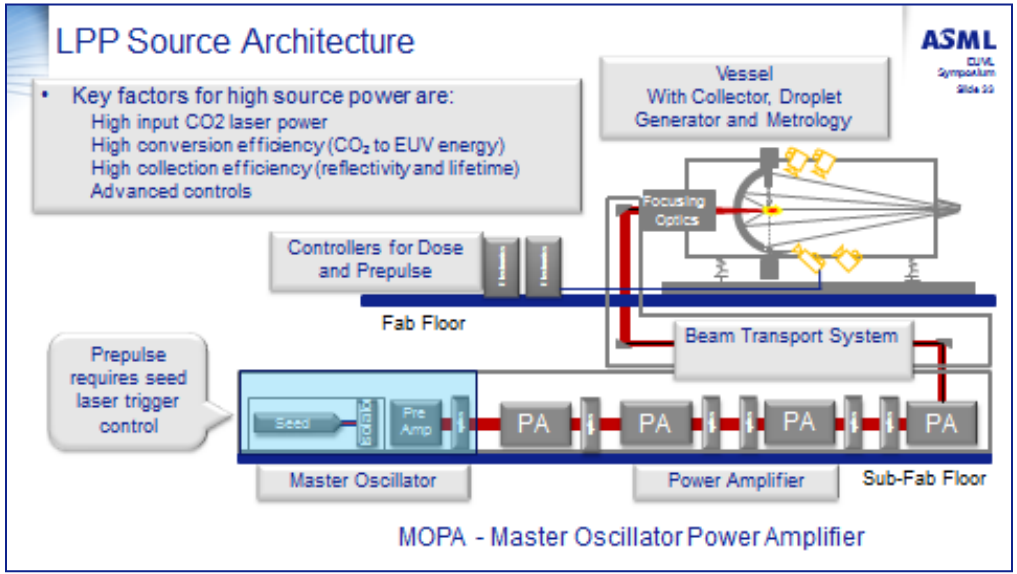


CD = 24.0 nm
LWR = 3.7 nm

- NXE:3100, NA=0.25, Conventional Illumination
- CDU difference of 0.18 nm
- Pellicle EUV transmission confirmed in imaging data: 85.5% (single pass)

Joint effort of NXE end users and ASML accomplished imaging results of half size pellicle

Source Aspects

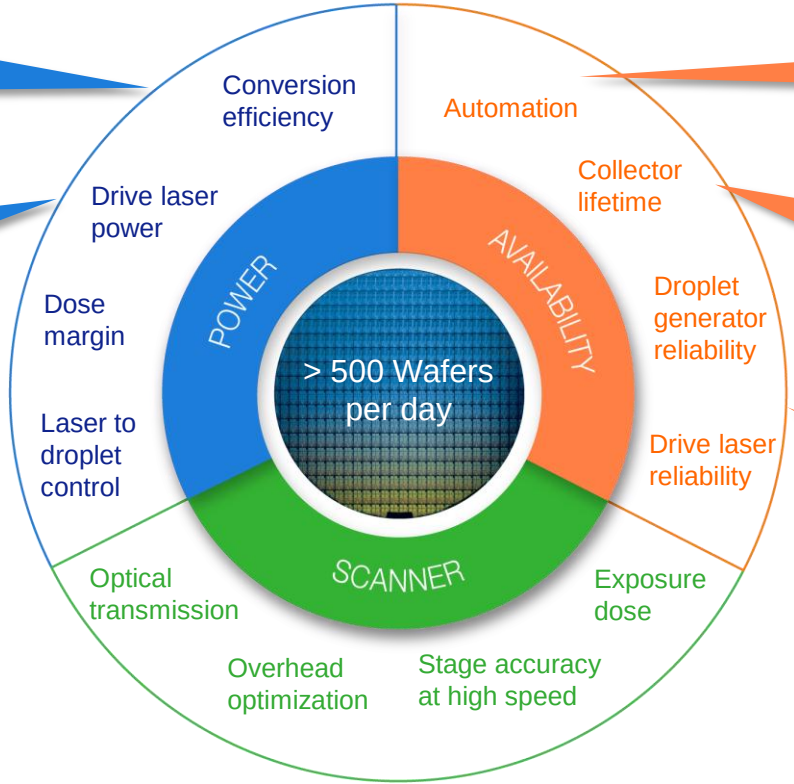


- Pre-pulse: Preparing Shape of Tin Target
- Main Pulse: Tin heating to proper state of matter (highly charged ions) and high temperature (200 kK) for continued EUV emission
- Pulse shaping in time and space for reduction of energy in particles and in ions and for increase of EUV radiation
- Protecting collector optics by hydrogen flow combining stopping and dynamic cleaning

250W / 125 wafers/hour LPP Power Scaling

Towards 250W EUV power with 4.5% CE CO_2 Drive Laser

Drive Laser Increase to more than 30 kWatt maintaining availability



Improved automation algorithms aslo for start-up

In-situ collector cleaning towards a dynamic equilibrium
Using hydrogen gas for stopping ions and cleaning collector

Increasing reliability of the droplet generator

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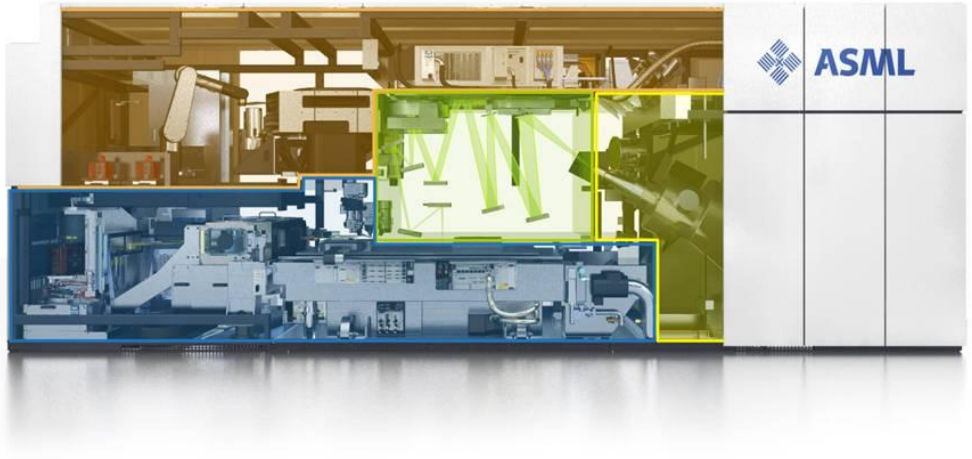
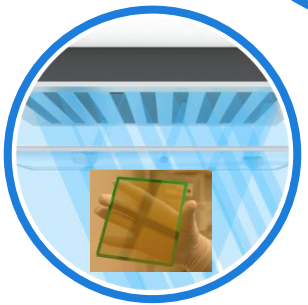
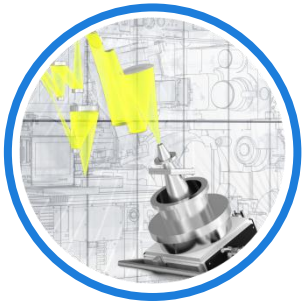


Summary: EUV towards production insertion

- Two customers demonstrated 500 wafer per day capability in endurance tests.
- System performance well within target at >40W source power



- Half-size EUV pellicle prototype has been tested successfully



- >40W stable performance at customers, 80W performance shown at ASML and being transferred to customers
- EUV source: Continuous Improvements on conversion efficiency, dose margin, automation, collector lifetime, driving power. Increasing reliability and availability

Acknowledgements

The work presented today, is the result of hard work and dedication of teams at ASML, Cymer, Zeiss, and many technology partners worldwide including our esteemed customers

Special thanks to our partners and customers for allowing us to use some of their data in this presentation

ASML