ASML

EUV Pellicle
Progress and Strategy

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Toyama, Japan

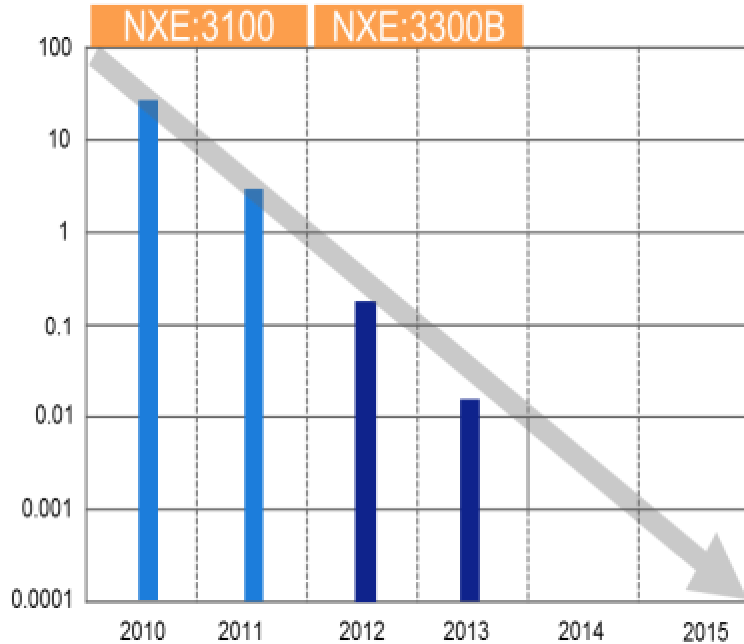
ASML EUV Pellicle Progress and Strategy

Agenda

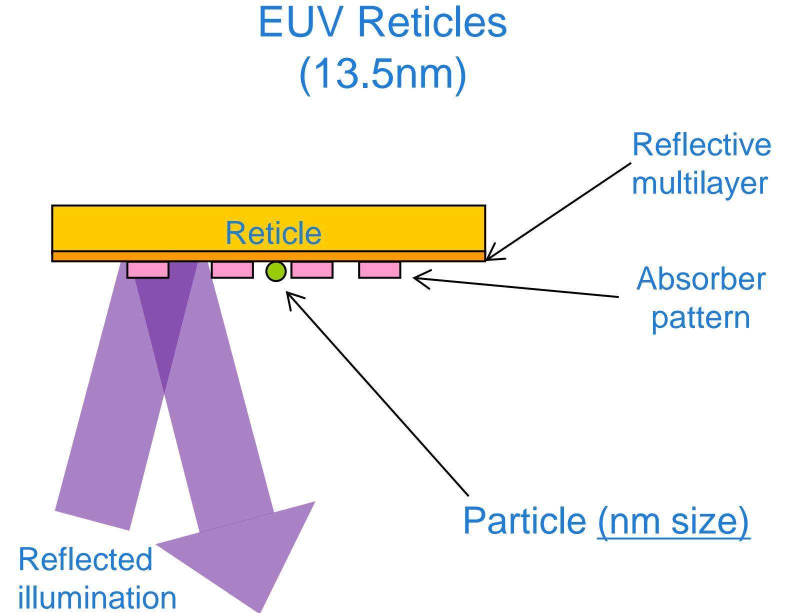
- The EUV mask particle defect challenge
- EUV pellicle requirements
- Overview testing for Phase 1 qualification
- Material qualification summary
- Imaging summary
- Next step: Phase 1
- Next step: Phase 2

The mask particle defect challenge

ASML achieved 10x per year improvement for pellicle-less operation (baseline is to build a clean scanner that meets customer requirements)



Progress made on ASML machines on added particles per reticle exchange over the past few years



Customer requirement for full production without pellicle @ resolution

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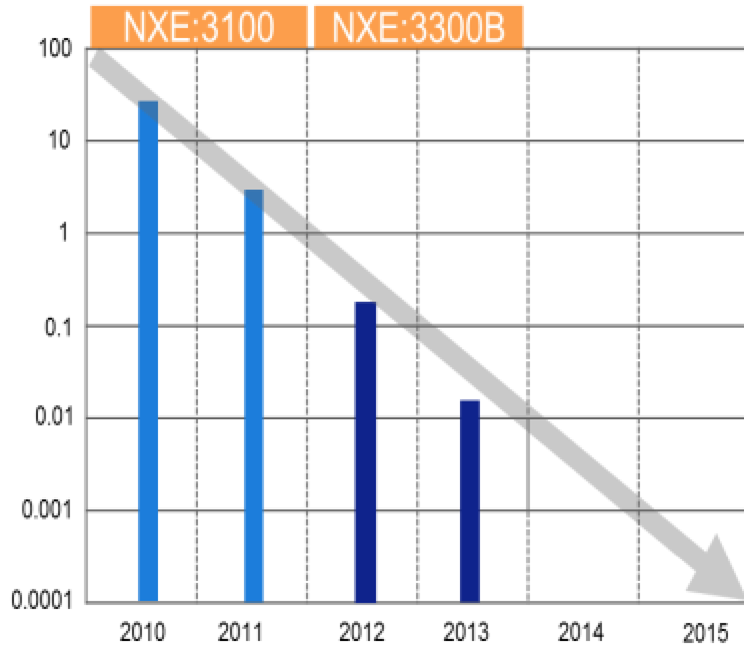

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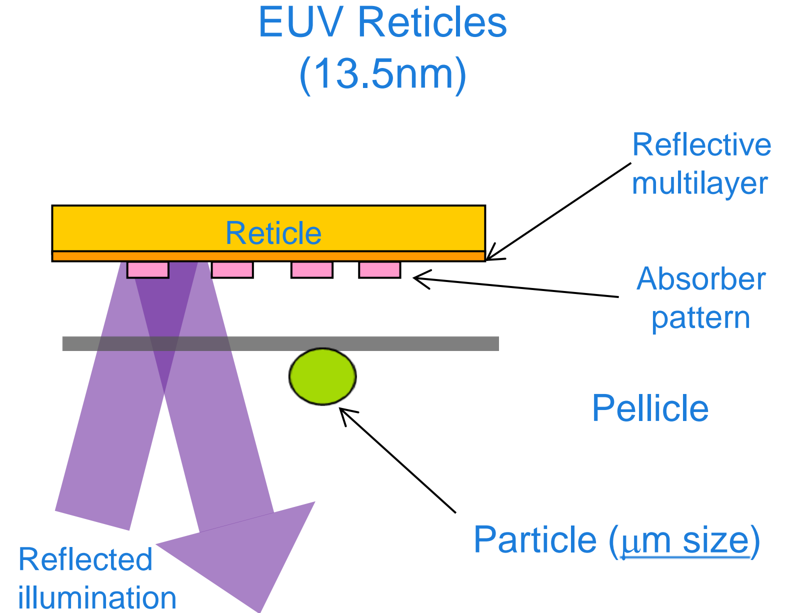
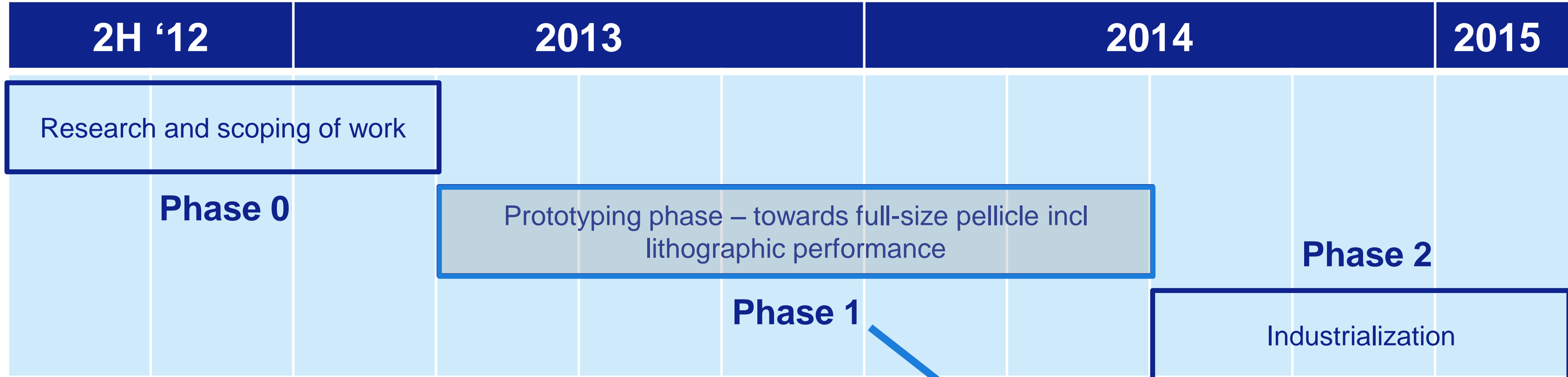


Customer requirement for full production without pellicle @ resolution

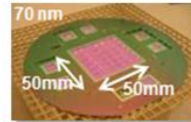
Proposed EUV pellicle requirements

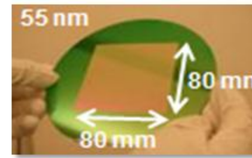
	Item	Requirement
Material requirements	EUV transmission	90% single pass (81% double pass)
	Size	Reticle inner reserved area: 110 x 144 mm Reticle outer reserved area: 117 x 151 mm } update planned Dec 2013
	EUV peak power in scanning slit @ reticle	5 W/cm^2 (250 W source)
	Lifetime (EUV+H_2)	>315 hrs (=4e5 J/cm^2 dose)
	Max. acceleration	100 m/s^2: during scanning, 200 m/s^2: end stops
Imaging requirements	EUV transmission spatial non-uniformity	<0.2% at reticle → CDU impact < 0.1nm
	EUV transmission angular non-uniformity	< 300 mrad max. local pellicle angle → CDU impact < 0.1nm
Pellicle + frame requirements	Standoff distance	2 ± 0.5 mm
	Max. pressure rate of change	3.5 mbar/s (peak during pump-down in the load lock)

ASML pellicle program now in Phase 1 started early 2013



- Tested EUV transmission, deflection, heat loads, imaging
- Next step: continue scaling towards half size





Good progress in free standing material development

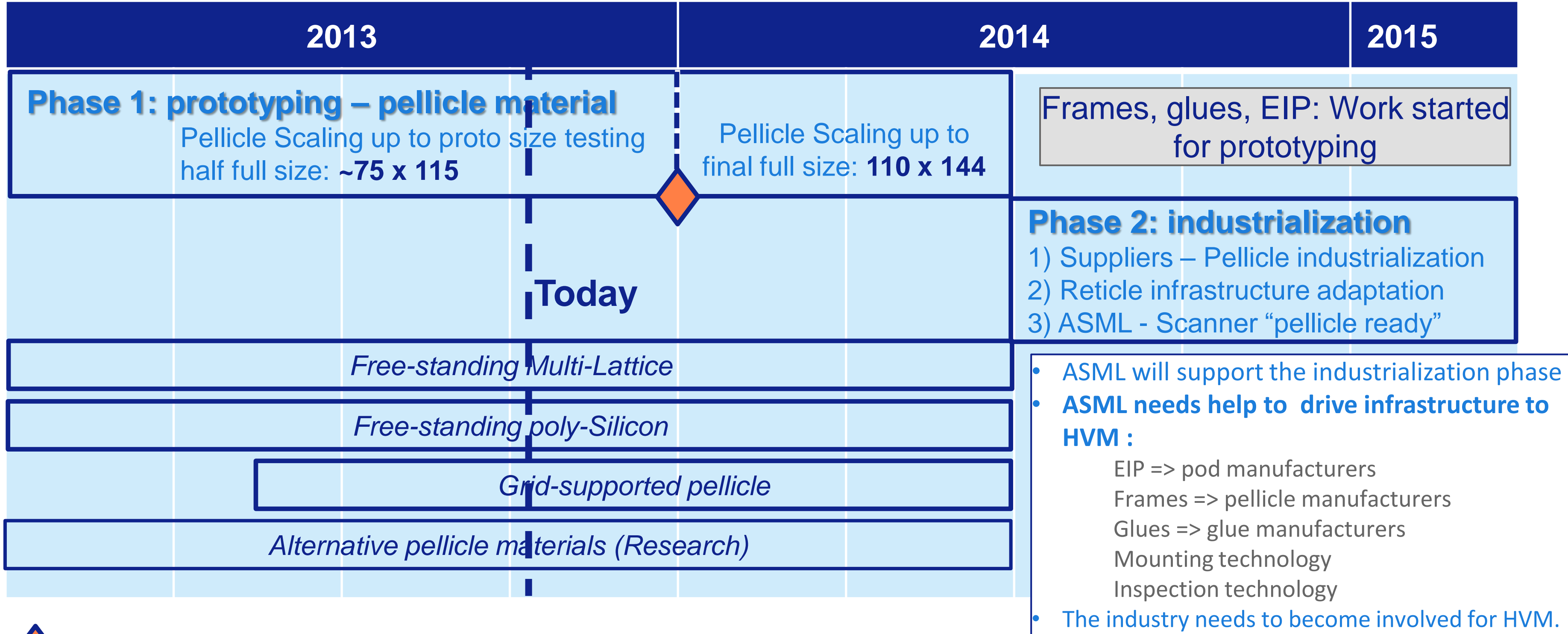
50mm x 50mm and 80mm x 80mm poly Si samples tested

½ size ~75mmx 115mm planned for 2013

full size ~110mmx 144mm planned for 2014

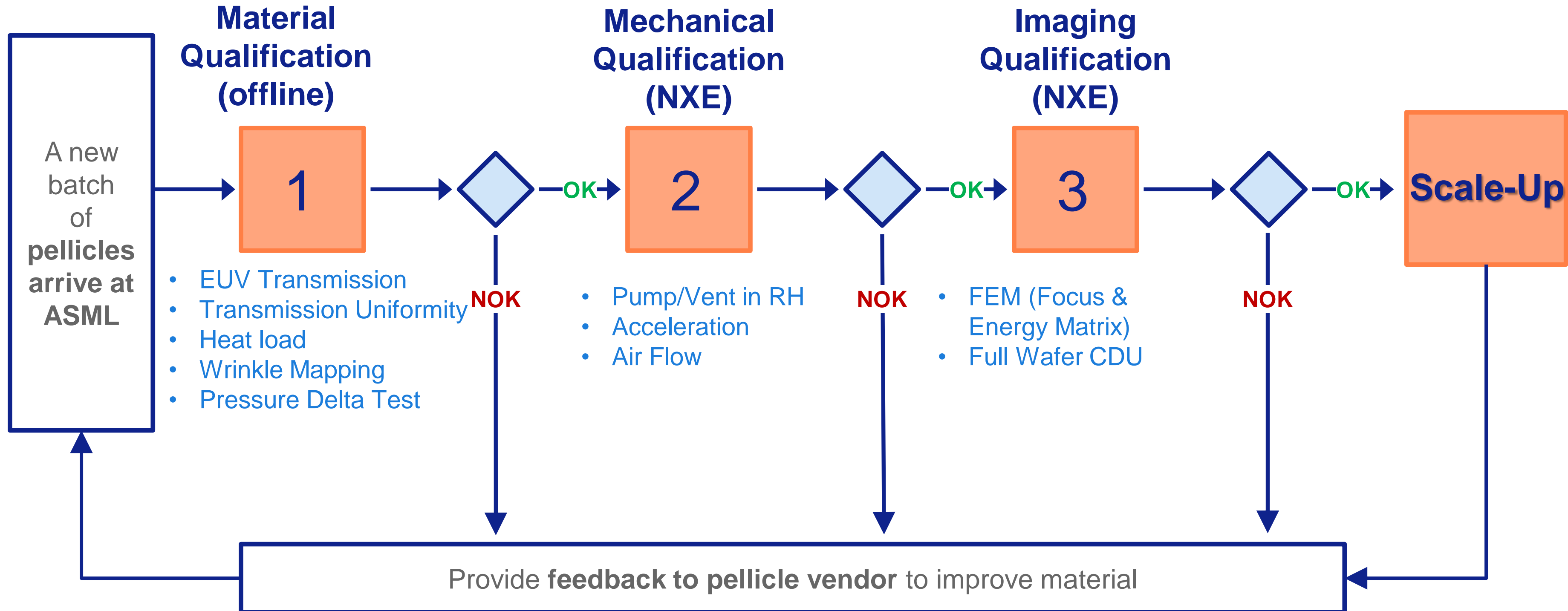
ASML EUV pellicle program

Phase 1: EUV Pellicle film feasibility study



End 2013: Intermediate EUV Pellicle Material Feasibility Review

Standard qualification tests performed for each pellicle

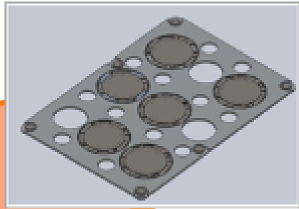


Current status of leading pellicle material

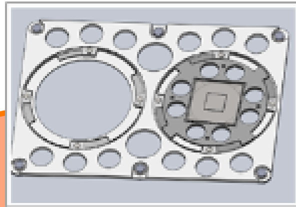
Material properties	Optical	Mechanical	Thermal			
	EUV transmission	Pellicle deflection (sagging)	Heat load (40 W)	Heat load (80 W)	Heat load (120 W)	Heat load (250 W)
Poly-Silicon	OK	OK	OK	OK	NOK	NOK

- **Poly-Silicon** material shows potential in meeting requirements for EUV pellicle
  - Improvements needed to meet the final requirements for EUV transmission and heat load.

Prototype frame design changes to support pellicle proto size scaling



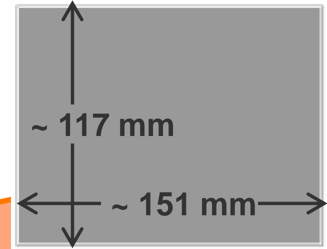
Supports:
20 mm ∅ round pellicles
ML - Phase 1A



Supports up to:
40 mm ∅ round &
20 x 20 mm^2 square pellicles
pSi - Phase 1A

Supports up to:
60 x 60 mm^2 square pellicles
pSi - Phase 1B,C,D
ML - Phase 1B,C,D

Needed to support:
75 x 115 mm^2
rectangular pellicles
pSi - Phase 1E
ML - Phase 1E



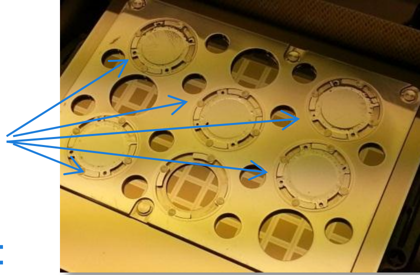
Needed to support:
110 x 144 mm^2
rectangular pellicles
Full size* - Phase 1F

Summary imaging tests results with pellicles

No measurable impact of pellicles in imaging (within measurement noise)

ML Imaging tests

5 pellicle positions
20 mm diameter,
25 nm thickness



Imaging performance:

- Small decrease in process window, difficult to calculate due to strong process fingerprint
- DOF range without pellicle limited by available focus fields on wafer

Defectivity performance:

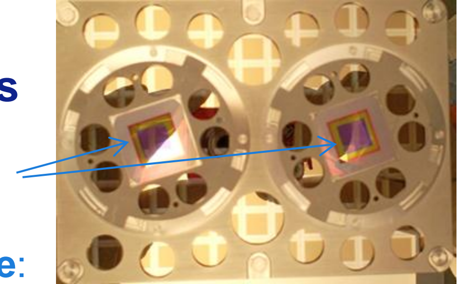
- Large printed particles (~ 30um to >100um) due to pellicle manufacturing/handling outside cleanroom

ML pellicle film quality:

- Impact of pellicle/wrinkles not visible

Poly-Si Imaging tests

2 pellicle positions
11mm x 11mm, 75 nm thickness



Imaging performance:

- No measurable difference w/ and w/out pellicle: no variation in exposure latitude and focus window (all within measurement noise, strong process fingerprint)

Defectivity performance:

- No measured printed particles in imaging data

pSi pellicle film quality:

- Variation in EUV transmission observed in CD variation; pellicle manufacturing process improvement required

Next step: Phase 1

- ASML has an active EUV pellicle project to develop and qualify a full size working EUV pellicle prototype by mid 2014.
- Includes project leader, team leads, material architect, and imaging expertise involvement along with customer collaborations, multiple film suppliers, marketing, purchasing, and ASML research support.

- If you have material films or other related capabilities to contribute to Phase 1, please contact:
  - Daniel Smith: daniel.smith@asml.com

Next step: Phase 2

- ASML will support the industrialization phase, but the mask infrastructure needs help to drive EUV pellicles to HVM :
  - EIP => pod manufacturers
  - Frames => pellicle manufacturers
  - Glues => glue manufacturers
  - Mounting technology
  - Inspection technology

Summary

We are making good progress demonstrating EUV pellicle feasibility

Infrastructure efforts are required to make EUV pellicles ready for HVM

Join in - this is important and useful work

For more details: see Proc. SPIE. 8679, Extreme Ultraviolet (EUV) Lithography IV 867904
Investigation of EUV pellicle feasibility