ASML NXE Pellicle progress update

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2016 EUV Mask Pellicle TWG
San Jose CA
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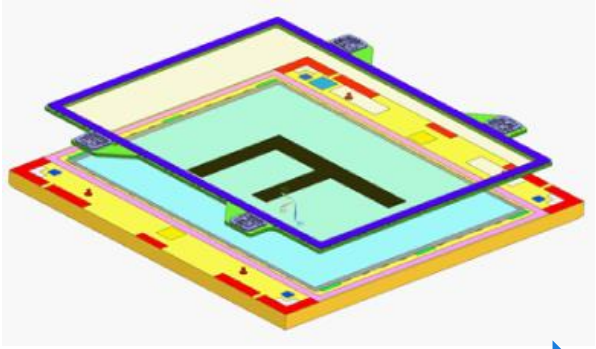
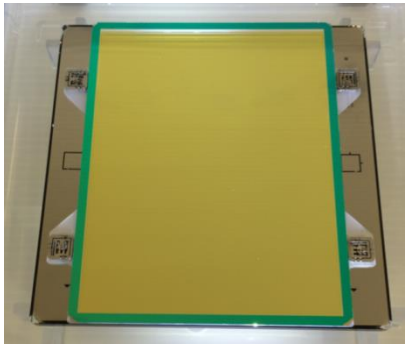
NXE pellicle development

NXE pellicle: from concept to reality

February 2015

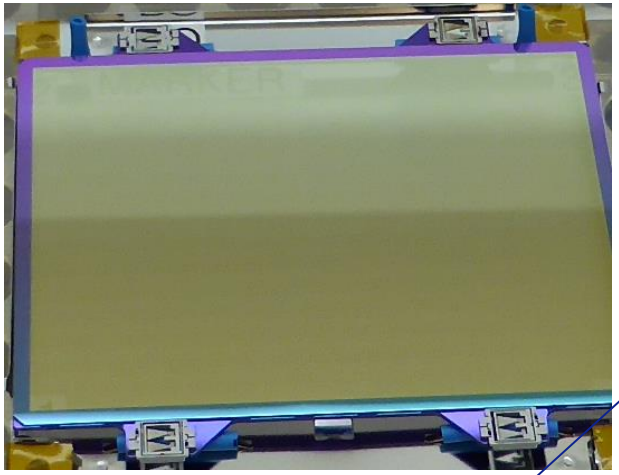


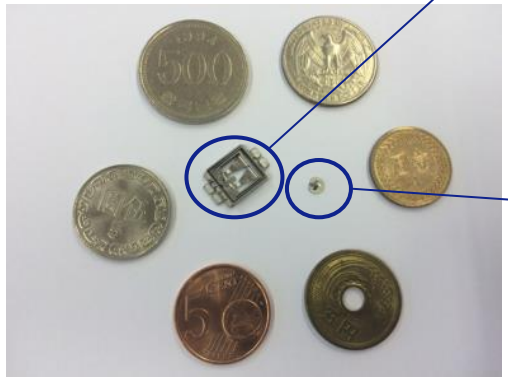
NXE pellicle concept



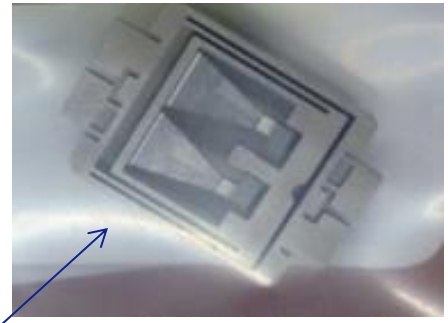
NXE pellicle demonstration model

Current design



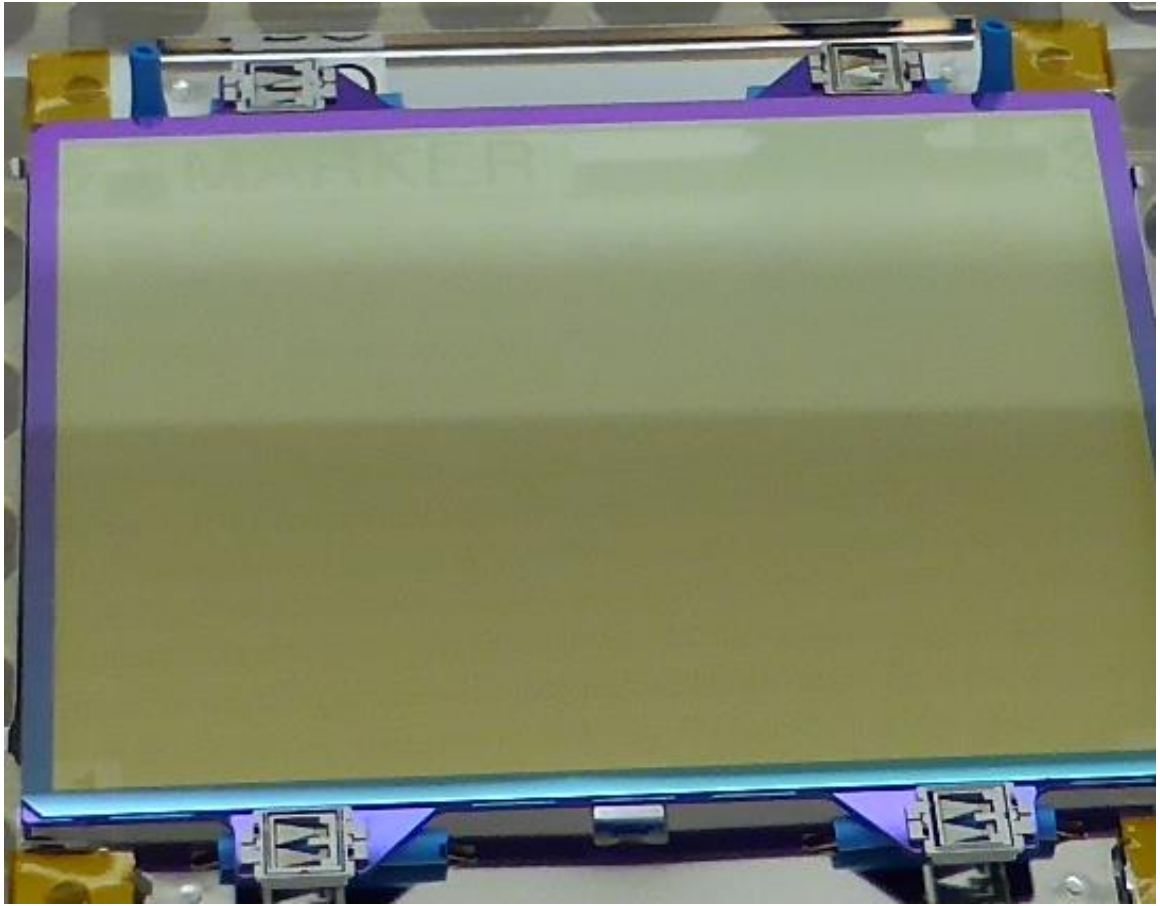


Fixtures



Studs
(interface to reticle)

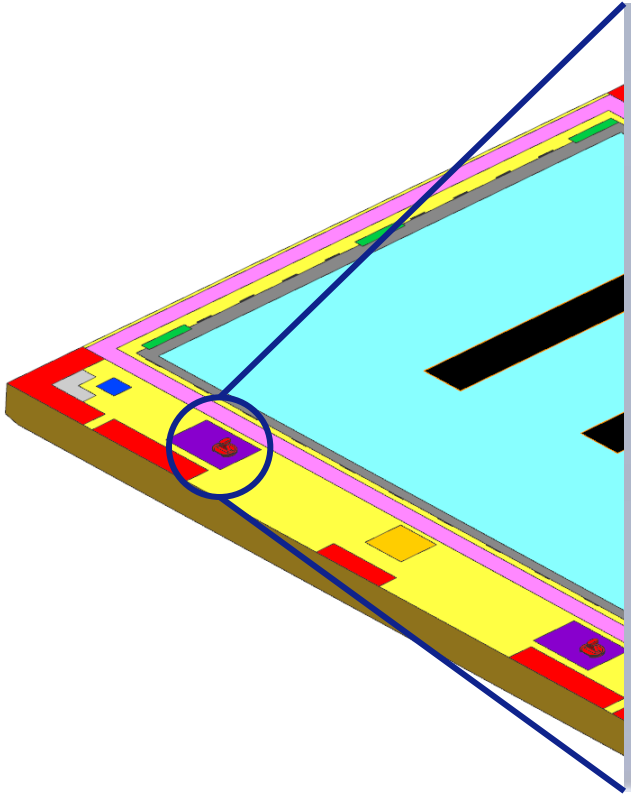
NXE Pellicles are being mounted on reticles and exposed



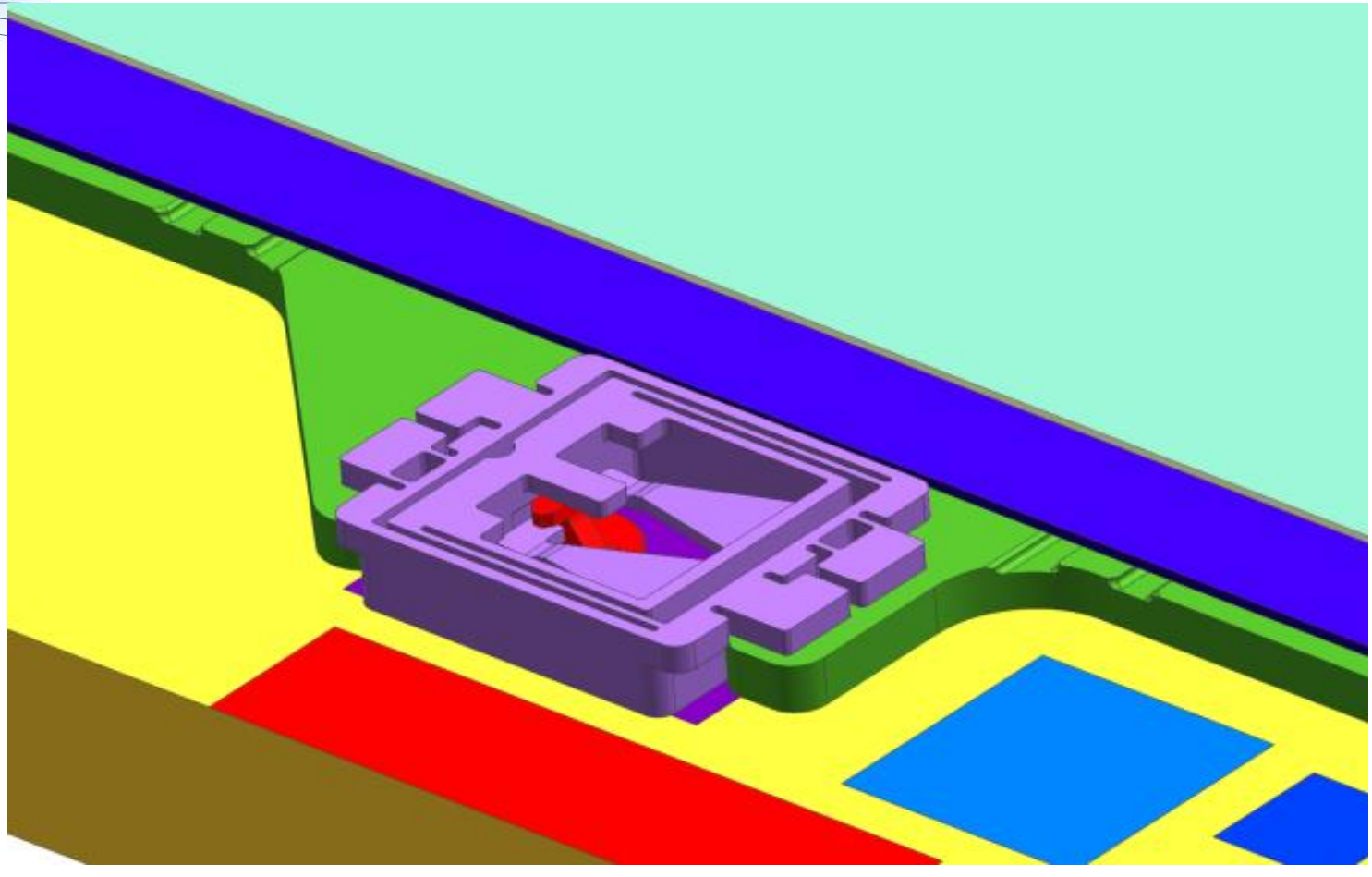
NXE pellicle update

NXE pellicle: from concept to reality

Mount-demount principle without any sliding motion

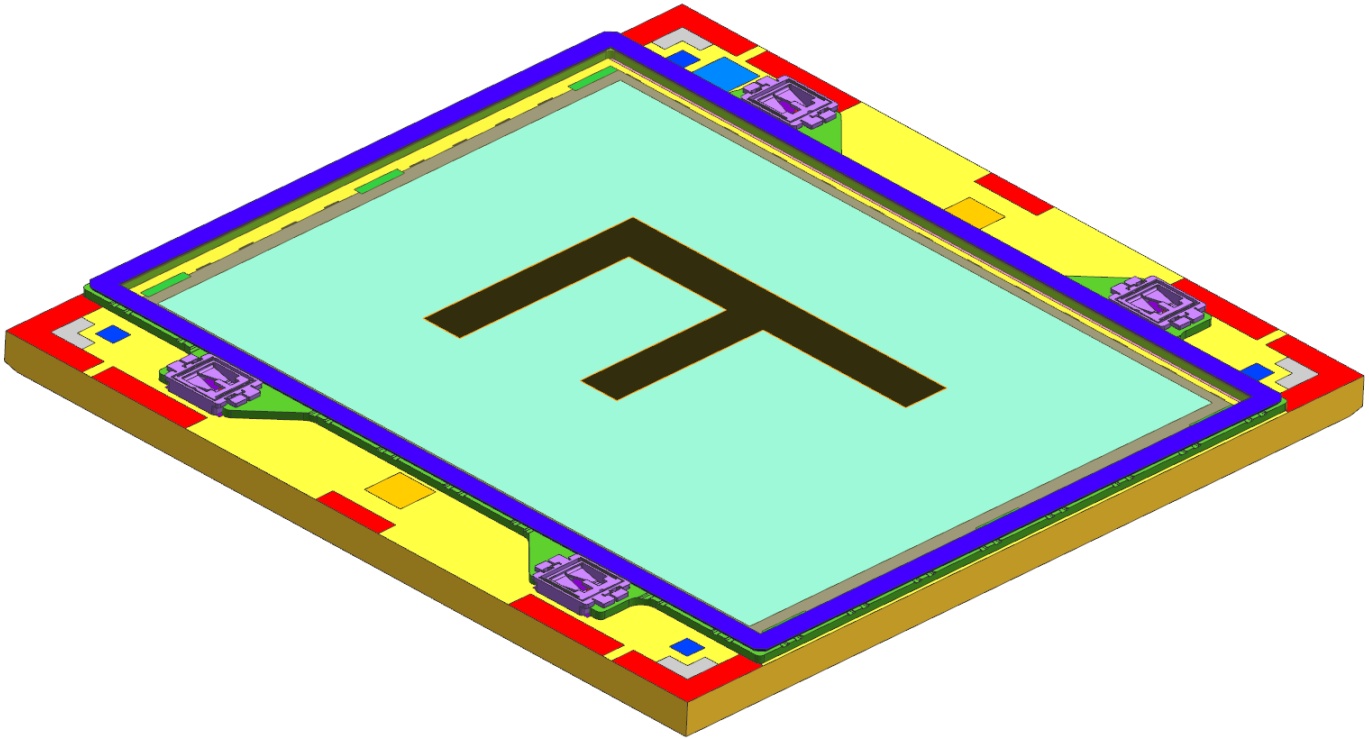


NXE pellicle: from concept to reality



NXE pellicle: from concept to reality

Close proximity mount to limit reticle deformation and allow venting



NXE pellicle tooling to support pellicle use in mask shops available 2nd half of 2016

Three tools developed:

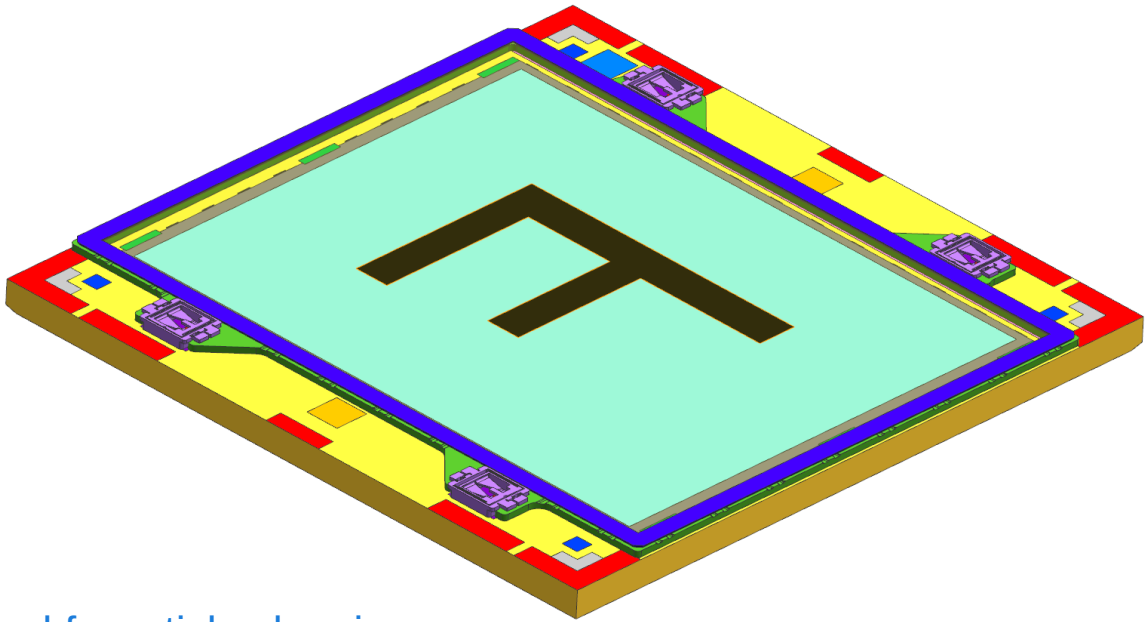
1. Mount studs
2. Mount, demount remount pellicle (→)
3. Remove studs

Key features:

- Optimized design for cleanliness
- No manual reticle or pellicle handling
- Mount-demount principle without any sliding motion.

NXE pellicle: from concept to reality

Removeable NXE pellicle allows for patterned mask inspection



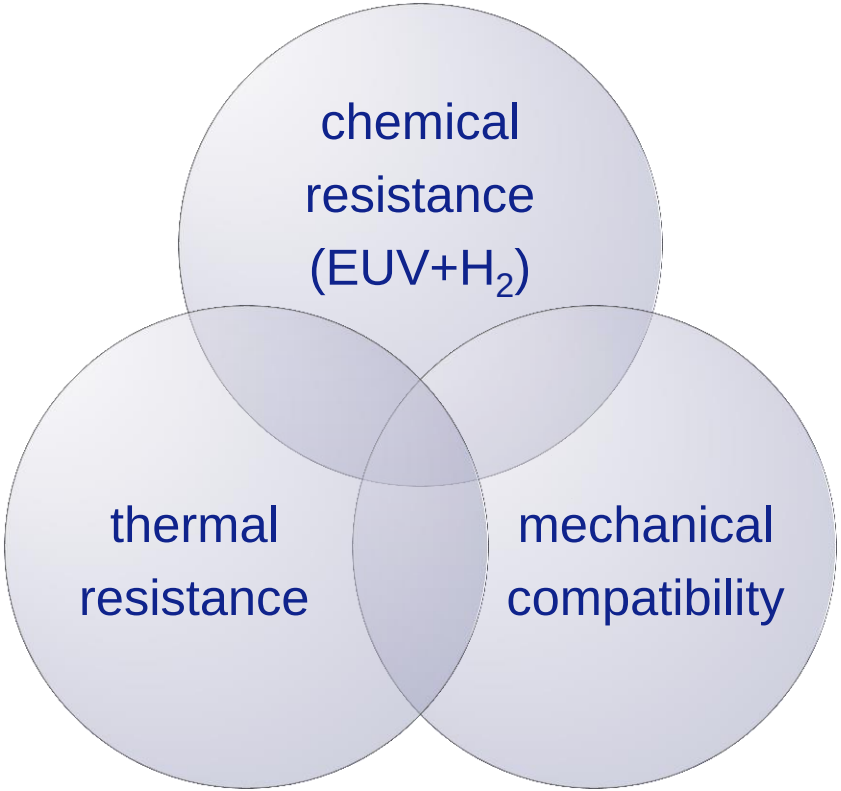
- Studs can be removed for reticle cleaning
- Alternatively, localized reticle cleaning could be done with the studs on

Pellicle Film Development

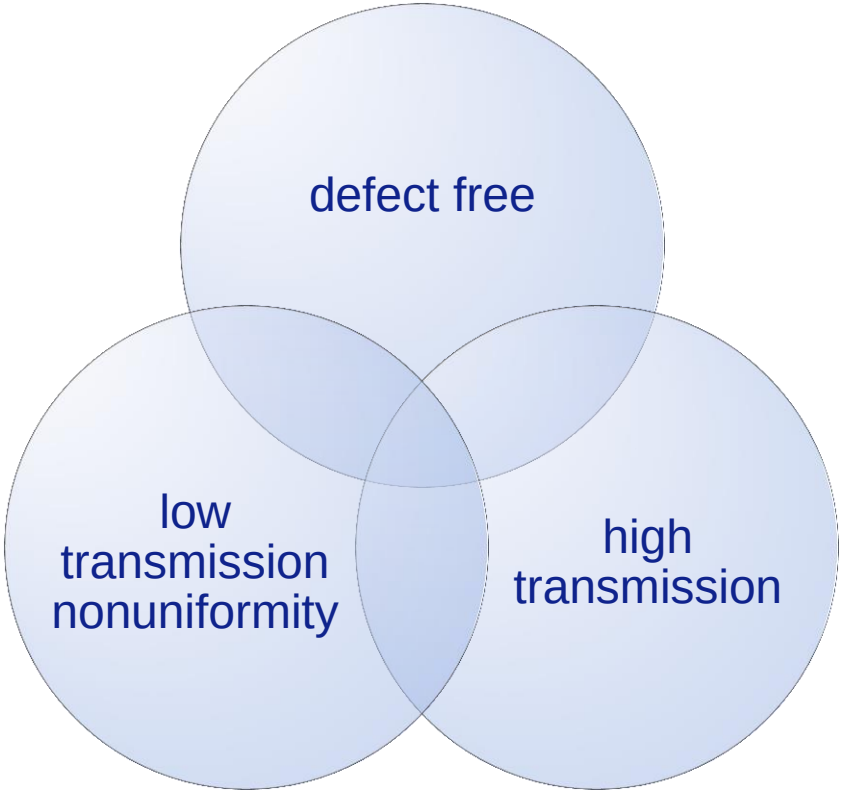
Pellicle film must simultaneously fulfill all key requirements

Polycrystalline silicon based films meet the key requirements

Pellicle robustness



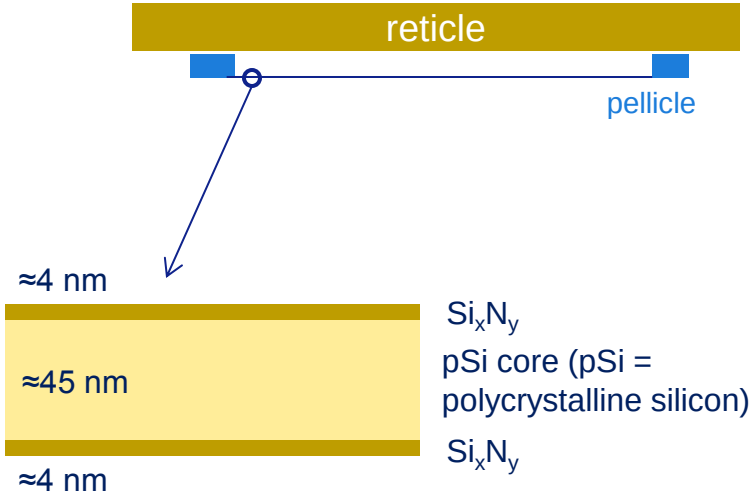
Scanner (imaging) performance



Pellicle film: Performance roadmap

Continuous improvement plan for pellicle films

Pellicle film generations	Product Phase	Target specifications: Transmission [1]	Target specifications: Transmission non-uniformity [2]	Target specifications: Power capability
	Prototype	>80%	1%	>40W
	Pilot	>80%	1%	>125W
	Product	88%	0.4%	250W
	Future	≥90%	0.4%	>250W



[1] Single pass transmission at 6 deg angle of incidence
[2] Half range; single pass

Pellicle film: Performance roadmap

Pilot film with increased power capability

	Product Phase	Target specifications		
		Transmission [1]	Transmission non-uniformity [2]	Power capability
Pellicle film generations	Prototype	>80%	1%	>40W
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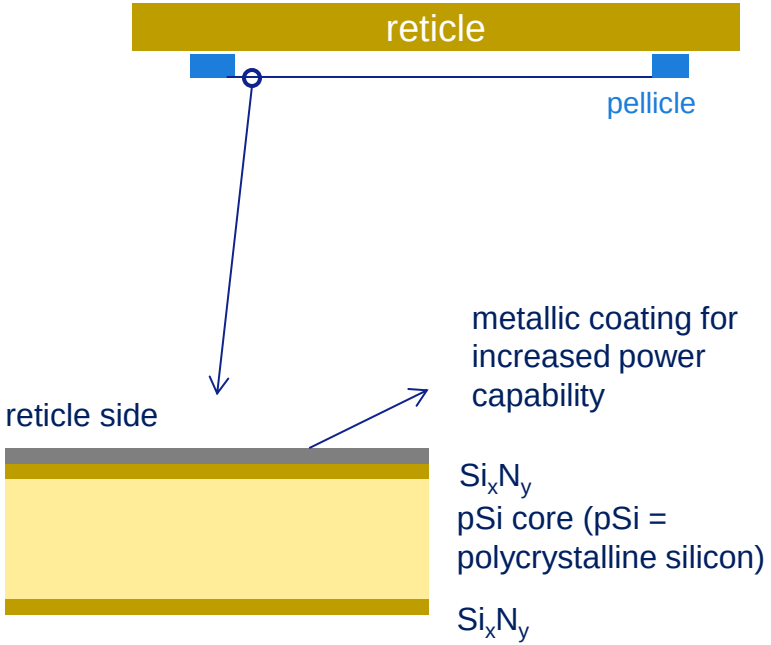

Pellicle film: Performance roadmap

Product film with new capping materials

Pellicle film generations	Product Phase	Target specifications: Transmission	Target specifications: Transmission non-uniformity	Target specifications: Power capability
	Prototype	>80%	1%	>40W
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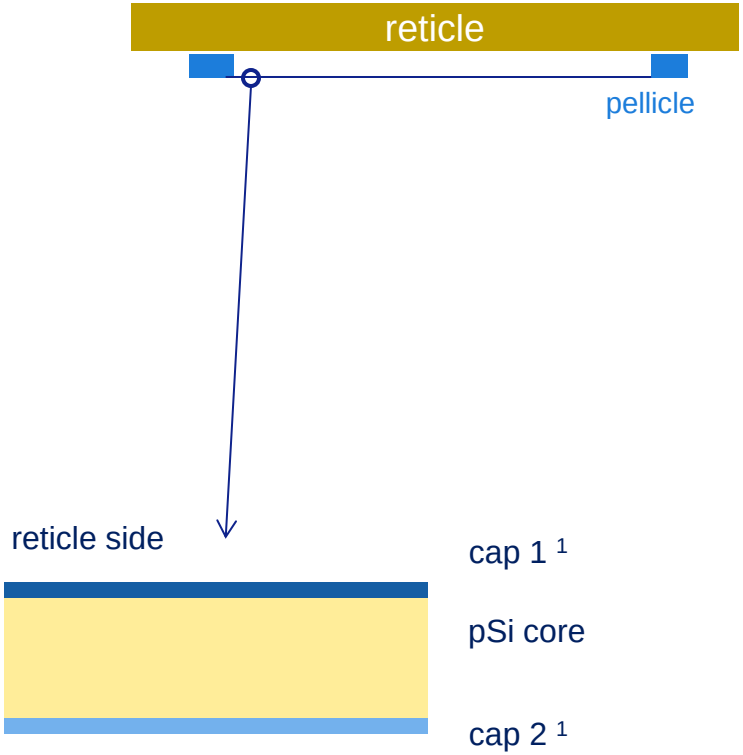
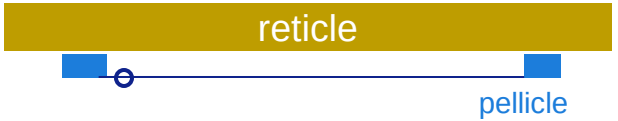


[1] Various materials are being characterized

Pellicle film: Performance roadmap

Research activities



	Product Phase	Target specifications		
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In parallel, ASML Research investigates pellicle robustness, primarily thermal resistance based upon:

- Graphene/carbon based membranes (96% transmission achieved on carbon based films)
- New multilayer structures
- High temperature ceramics as capping and base material

NXE Scanner readiness

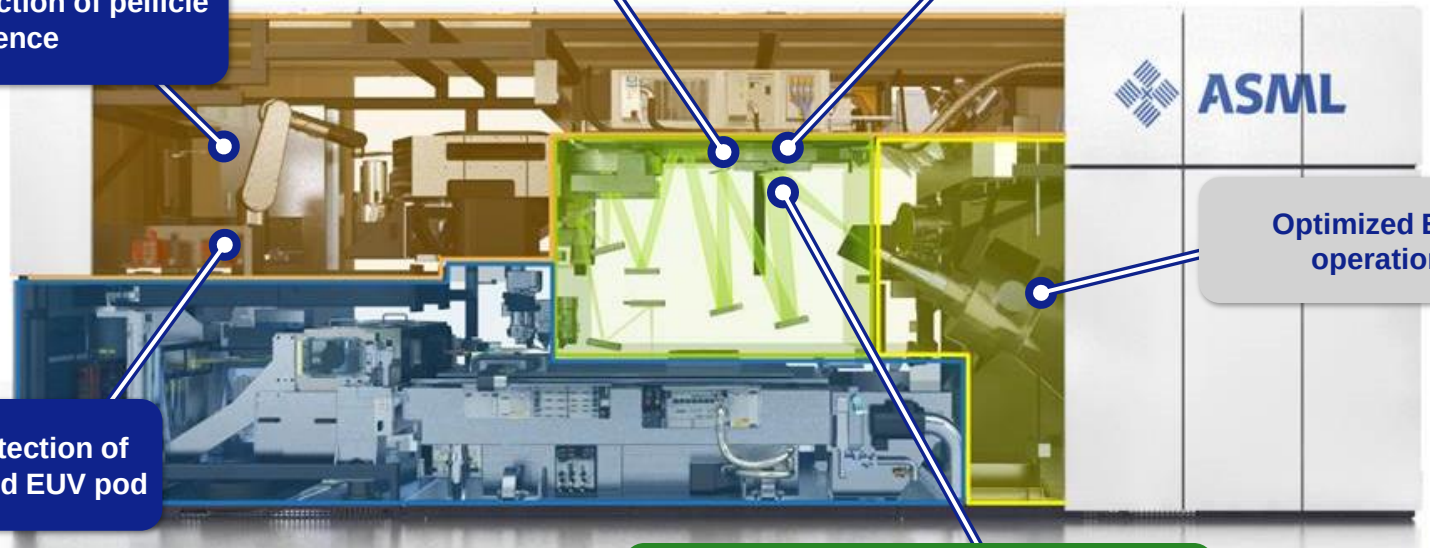
NXE scanner readiness for robust operation with pellicle

Prevention
Detection
Recovery

Optimized scanner flow configuration

Reticle stage: detection of pellicle presence between exposures

Load lock: detection of pellicle presence



Optimized EUV source operation modes

Load lock: detection of pellicle modified EUV pod

Protocol established and tested in preparation for any pellicle failure event

200 wafers exposed using reticle with 40W pellicle

Collaborative effort between Intel and ASML

ASML

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19-Feb-16

200 wafers exposed with NXE Pellicle

- **NO RETICLE ADDERS OBSERVED IN WAFER PRINTS**
- **Particles on pellicle do not appear to migrate to reticle surface**
- **ASML pellicle frame design is mitigating adder rate**
  - **defectivity assessment continuing**

EUV defectivity reticle shipped

- **Global transport**
- **Multiple location handling**

Exposure testing will continue to 1000+ wafers with NXE Pellicle

Summary

- NXE Pellicle has moved from concept to realization phase
- Mask shop tooling to support NXE Pellicle in mask shop flow is defined. Development is driven to achieve defect free mounting and demounting
- Pellicle film roadmap established with plan to support higher EUV powers and improve imaging performance
- NXE scanners can be adapted with multiple new features for robust NXE Pellicle operation.

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