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NXE pellicle development
NXE pellicle: from concept to reality

February 2015

NXE pellicle concept

Current design

Fixtures

NXE pellicle demonstration model

Studs
(interface to reticle)
NXE Pellicles are being mounted on reticles and exposed.

Slide 4
Public
21-Feb-16
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 2\textsuperscript{nd} 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
- Chemical resistance (EUV+$H_2$)
- Thermal resistance
- Mechanical compatibility

Scanner (imaging) performance
- Defect free
- Low transmission nonuniformity
- High transmission
Pellicle film: Performance roadmap
Continuous improvement plan for pellicle films

## Target specifications

<table>
<thead>
<tr>
<th>Product Phase</th>
<th>Transmission(^1)</th>
<th>Transmission non-uniformity(^2)</th>
<th>Power capability</th>
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<tbody>
<tr>
<td>Prototype</td>
<td>&gt;80%</td>
<td>1%</td>
<td>&gt;40W</td>
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<tr>
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<td>1%</td>
<td>&gt;125W</td>
</tr>
<tr>
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<td>250W</td>
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<tr>
<td>Future</td>
<td>≥90%</td>
<td>0.4%</td>
<td>&gt;250W</td>
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</table>

\(^1\) Single pass transmission at 6 deg angle of incidence
\(^2\) Half range; single pass
# Pellicle film: Performance roadmap

Pilot film with increased power capability

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</table>

- **Pellicle film generations**

- **Reticle side**
  - Metallic coating for increased power capability
  - $Si_xN_y$
  - pSi core ($pSi = polycrystalline silicon$)
### Pellicle film: Performance roadmap

**Product film with new capping materials**

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<td>Future</td>
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</tbody>
</table>

1 Various materials are being characterized.

![Diagram]

### Pellicle film generations

- **Reticle side**
  - cap 1
  - pSi core
  - cap 2

- **Pellicle**
Pellicle film: Performance roadmap
Research activities

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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**

Load lock: detection of pellicle presence

Optimized scanner flow configuration

Reticle stage: detection of pellicle presence between exposures

Load lock: detection of pellicle modified EUV pod

Optimized EUV source operation modes

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

- 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.