EUV Interference Lithography at PSI

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EUV-IL Exposure System

- Class 1000 cleanroom
- Chemically filtered air (amines)
- Sample stage for 4 – 8” wafers
- Stage travel range 80x80 mm
- PEB next to exposure tool
- Sample-coating/development in separate cleanroom
- NO outgassing requirement
- Throughput: ~1 wafer/hour (50-100 doses)

- Constant beam current at SLS (top-up), stable and constant illumination
- Illumination flux measured before exposure monitored afterwards
The Interferometer

- Based on transmission diffraction gratings patterned on SiN membranes
- Diffraction gratings made in-house with e-beam lithography or EUV-IL
- No alignment – no focus ➞ same image each time
- High-contrast as deduced from resist performance

**2-Beam Interference**
- Line/space patterns

**4-Beam Interference**
- Square hole array

**Diffraction Gratings**
100 nm L/S mask

EUV Resist TWG, Sapporo 2007
EUVIL Test Results with PMMA

50 nm half pitch

45 nm

40 nm

35 nm

30 nm
EUVIL Test Results with HSQ

50 nm half pitch
45 nm
40 nm
35 nm
30 nm
20 nm
Calixarene

TEBN-1 Tokuyama Co

Film thickness: 20-30 nm

Development: IPA, 30 s

EUV Resist TWG, Sapporo 2007
<table>
<thead>
<tr>
<th>Pattern Width</th>
<th>L/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>50um</td>
<td>50nm</td>
</tr>
<tr>
<td>800um</td>
<td>800μm</td>
</tr>
<tr>
<td>50um</td>
<td>45nm</td>
</tr>
<tr>
<td>800um</td>
<td>800μm</td>
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<tr>
<td>50um</td>
<td>40nm</td>
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<td>800um</td>
<td>800μm</td>
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<tr>
<td>50um</td>
<td>35nm</td>
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<td>800μm</td>
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<tr>
<td>50um</td>
<td>30nm</td>
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<td>800um</td>
<td>800μm</td>
</tr>
<tr>
<td>50um</td>
<td>25nm</td>
</tr>
<tr>
<td>800um</td>
<td>800μm</td>
</tr>
</tbody>
</table>

- 25-50 nm L/S printed simultaneously
- 800 μm long cleavable lines
- Pattern width: 50-100 μm
Pattern on Wafer

Low magnification SEM image of pattern in HSQ

EUV Resist TWG, Sapporo 2007
EUVIL Test Results with HSQ

- Low-magnification image of 30 nm L/S pattern
Multiple-beam EUV-IL

24.7 nm HP - PMMA
21.2 nm HP - HSQ
17.1 nm HP - HSQ
### Dot Position and Size Uniformity

**Average (nm) | Stdev (1 sigma, nm) | Stdev/Average**

<table>
<thead>
<tr>
<th>Direction</th>
<th>Dot-to-Dot Distance</th>
<th>Average</th>
<th>Stdev</th>
<th>Stdev/Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>59.9</td>
<td>0.5</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>59.9</td>
<td>0.5</td>
<td>0.8%</td>
<td></td>
</tr>
<tr>
<td>A'</td>
<td>42.7</td>
<td>0.6</td>
<td>1.4%</td>
<td></td>
</tr>
<tr>
<td>B'</td>
<td>42.0</td>
<td>0.5</td>
<td>1.3%</td>
<td></td>
</tr>
<tr>
<td>Dot size in plane</td>
<td>25.8</td>
<td>0.4</td>
<td>1.7%</td>
<td></td>
</tr>
</tbody>
</table>

Analysis by Justin Hu, Kim Y. Lee, David Kuo, Dieter Weller, Seagate Technology

EUV Resist TWG, Sapporo 2007
Other Resist Development

Block-copolymers
P. Nealey, UW

ZnO
PSI

Nano-grafting
PSI

EUV Resist TWG, Sapporo 2007
Access

- Limited number of shifts are available
- Resist receiving, storage, coating, exposure, development, shipping
  ~ USD 6500 /shift
- State of the art SEM available for top-down imaging (fee)
- Schedule made for 6-month periods (Jan-Jun, Jul-Dec)
- Contact: harun.solak@psi.ch
Next Generation EUV-IL at PSI

- Full-time beamline with undulator source under construction
- Capacity increase 6x
- Processing equipment (coating, development) near exposure tool
- Completion in 2009
- Open for long-term contracts and shift access (outgassing?)