Resist Based Dose Calibrations Update

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Resist TWG, EUV 2008 Symposium
October 2, 2008
ASML has verified the parameters and assumptions for the Eo tests by LBNL and NIST

- In May 2008, LBNL and NIST reported on new Eo measurements for two resists: R&H TOK P1123 and (LBNL only) MET1K (XP4502-D)
- Metrology at both LBNL and NIST were reviewed by ASML and confirmed to be good
- As a result of the NIST and LBNL work, a 1.9x correction was determined as necessary for all METs as reported in May 2008
The results of the LBNL new $E_0$ measurements were presented in May 2008

**$E_0$ measurement at BL6.3.2**

- Two independent measurements of RHEM MET-1K and TOK EUVR-P1123 done, respectively

<table>
<thead>
<tr>
<th>Date</th>
<th>Beamline current</th>
<th>MET-1K: $E_0$</th>
<th>P1123: $E_0$</th>
<th>PAB</th>
<th>PEB</th>
<th>Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/07</td>
<td>~20 mA</td>
<td>7.6 mJ/cm²</td>
<td>5.6 mJ/cm²</td>
<td>130/60, PEB 120/90, Dev 45s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/07</td>
<td>~250 mA</td>
<td>7.3 mJ/cm²</td>
<td>6.0 mJ/cm²</td>
<td>130/60, PEB 120/90, Dev 45s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average $E_0$**

- MET-1K: 7.45 mJ/cm²
- P1123: 5.8 mJ/cm²

*XP4502-D Note that ASML uses XP4502-J*
NIST reported results in May 2008 showing a match to the LBNL results

**NIST Results (Resist B)**

<table>
<thead>
<tr>
<th>Run</th>
<th>NIST $E_0$ (mJ/cm$^2$)</th>
<th>Intel MET $E_0/1.9$ (mJ/cm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.72</td>
<td>6.30</td>
</tr>
<tr>
<td>2</td>
<td>6.33</td>
<td>6.58</td>
</tr>
<tr>
<td>3</td>
<td>5.75</td>
<td>-</td>
</tr>
<tr>
<td>Avg</td>
<td>5.9</td>
<td>6.44</td>
</tr>
</tbody>
</table>

Resist B = TOK P1123
ASML has verified the parameters and assumptions for the Eo tests by LBNL and NIST

- In May 2008, LBNL and NIST reported on new Eo measurements for two resists: R&H TOK P1123 and (LBNL only) MET1K (XP4502-D)
- Metrology at both LBNL and NIST were reviewed by ASML and confirmed to be good
- As a result of the NIST and LBNL work, a 1.9x correction was determined as necessary for all METs as reported in May 2008
Data has been collected that confirms the ADT calibration as matching the NIST calibration

- Resist Eo has been checked on the ADT and compared to NIST and MET data
- Results confirm that the ADT matches the NIST calibration within uncertainty limits
  - Resist variation and processing differences were identified
  - All tools (METs, NIST and ADTs) use different processing (e.g., baking – contact vs. proximity)
- The next sheet shows results as tested by Intel, confirming that between NIST, MET and ADT, the TOK P1123 Eo data matches
- In addition, NIST has measured for ASML two additional resists, providing additional confirmation that all results are in agreement
TOK EUVR-P1123 ME E0 Data
IMEC ASML EUV ADT

Friday July 25th, 2008
IMEC ADT
E0 for EUVR-P1123 ME 6.2 mJ/cm²

Previously published resist calibrations:
IEUVI Resist TWG (SPIE Feb. 2008)
LBNL BL6.3 (with calibrated photodiode)
‘New’ E0 for EUVR-P1123 ME 5.8 mJ/cm²
(ave. of two measurements one month apart:
5.6 mJ/cm² and 6.0 mJ/cm²)

Sematech Litho Forum (May 2008)
NIST SURFIII (with calibrated photodiode)
E0 for EUVR-P1123 ME 5.9 mJ/cm²

Conclusion: IMEC ASML EUV ADT matches ‘new’
EUV resist calibration standards
(or is at least very close... ≈ 6% high)
**TOK EUVR-P1123 ME**
**IMEC ADT Comparison to Intel MET**

**Graph Description:**
- **TOK EUVR-P1123 ME E0 / Contrast**
- **x-axis:** Dose (mJ/cm²)
- **y-axis:** Thickness (nm)

**Key Points:**
- **MET Old Cal.:** E0 ≈ 12.5 mJ/cm²
- **MET New Cal.:** E0 ≈ 5.75 mJ/cm²
- **ADT E0:** ≈ 6.2 mJ/cm² (≈8% higher than MET new calibration)

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*Resist TWG, EUVL Symposium, September 29 - October 2, 2008*  
*Slide 8*
Data has been collected that confirms the ADT calibration as matching the NIST calibration

- Resists have been checked on the ADT and Eo compared to NIST and MET data, and the results confirm that the ADT matches the NIST calibration within the uncertainty limits
  - Resist variation and processing differences were identified
  - All METs and NIST and ADTs use different processing (e.g., baking – contact vs. proximity)
- The next sheet shows results as tested by Intel, confirming that between NIST, MET and ADT, the TOK P1123 Eo data matches
- NIST has measured for ASML two additional resists, providing further confirmation that all results are in agreement
**Estimated uncertainty factors influence resist based dose calibration**

<table>
<thead>
<tr>
<th>Component</th>
<th>Sub Component</th>
<th>NIST [± %]</th>
<th>ASML [± %]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure Tool</td>
<td>Radiometry</td>
<td>Dose Performance</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Spectral power stability (DUV)</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Resist</td>
<td>Resist contrast (dE/dFT)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Unexposed resist loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measurement accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Batch stability</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Process (SB, PEB, dev)</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Process variation (Difference)</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Total Variation</td>
<td></td>
<td>15</td>
<td>17</td>
</tr>
</tbody>
</table>
Three resists have been tested confirming ADT matching to NIST calibration.

![Graph showing resist performance](image)

ASML calibration standard uses $E_0 = 2\text{mJ/cm}^2$ for XP 4502J.
Summary

- ASML uses resist based dose calibration to set up the ADTs
  - XP4502-J; \( E_0 = 2 \text{ mJ/cm}^2 \) is the calibration resist
- METs match NIST dose calibration after calibration correction of 1.9x
- ADTs match NIST dose calibrations without corrections
  - Source output and optical efficiency for ADT, and also machine process and methodology for calibration, are correct
  - Throughput and dose as reported previously are correct
- Both ADT and MET can be used for resist work, knowing that calibrations match within the uncertainties of using resist for calibration, but.....
- *Industry needs a sensor that can be used on HVM EUVL systems for dose calibration*