Sept 2013 Resist TWG Survey Results

Karen Petrillo – SEMATECH/IBM
Serge Tedesco – CEA-LETI
Kyoungyong Cho – SEMATECH/Samsung
IEUVI Resist TWG Attendance

52 people attended

- Consortia
- Univ/Govt
- Material supplier
- Tool supplier
- Chip manufacturer
Meeting Focus

• **Outgas testing**
  – Major issue limiting materials research and development. Focusing on this issue for the past several meetings
    • Testing availability is improving
    • Ability to research topics related to outgassing is becoming available

• **Interest in DSA as a means to compliment traditional lithography**
Agenda

Welcome and Introductions
K. Petrillo, SEMATECH

NIST Outgas Testing Update
S. Hill, NIST

EIDEC Outgas Test Results
T. Takahashi, EIDEC

ROX Outgas Testing Update
G. Denbeaux, CNSE

IMEC Outgas Testing Update
I. Pollentier, IMEC

Break

EUVT Outgas Testing Update
R. Perera, EUV Technology

DSA as a Mean for EUV Contact Rectification
R. Gronheid, IMEC

DSA as Complementary Lithography: Guiding Pattern Requirements for Contact Shrink and Contact Multiplication
R. Tiron, CEA-Leti

Summary
S. Tedesco, CEA-Leti
NIST update, Shannon Hill

• 21 customer samples tested to date, 100 % passing

• Focusing on metrology

Some facilities are having problems exposing high E0 materials in the 1 hour window.

  - Expose for longer time
  - Expose a smaller area in an hour

Need to make sure you are working in the contamination limited zone

High partial pressures during outgassing can result in non-mass-limited CG and hence underestimates for outgas-testing CG for either EUV or e-beam exposures.

• Mass-limited growth should be verified for high-outgassing resists (e.g., check that CG thickness profile does NOT follow intensity profile of beam.)
EIDEC update, Eishi Shiobara

- 60 customer samples tested, 80% passing
- Studied the effect of formulation and process parameters on contamination growth, and recommended ways to reduce testing

  - Considering protecting unit ratio and PAG loading; clear correlation with contamination thickness was obtained for both parameters. However, this correlation was not the same for dose.

  - Considering quencher loading and PEB temperature; clear correlation with contamination thickness was obtained for both parameters. For these parameters, a clear correlation with dose was also observed.

  - Guidelines on resist outgas test sample reduction were suggested. (based on evaluated data)
81 customer samples tested, 55% passing
Residual contamination from stray electrons discussed
Residual contamination in the chamber
  2 hour delay between samples is the current methodology to deal with chamber outgassing
High E0 samples
  No correlation between high E0 samples and CG
IMEC update, Ivan Pollentier

- 69 customer samples tested, 70% passing
- Good correlation of RGA to CG on witness sample
  - Suggestion from audience to use RGA as a screening method, and only do WS testing for samples that are on the pass/fail borderline

Check of correlation in 72 resist tests so far
EUVT update, Rupert Perera

- 3 customer samples tested, tool is currently undergoing maintenance
- Showed good repeatability testing
- Residual contamination from stray electrons is an issue
  - Oxygen plasma cleaning is not the answer

High throughput tool – plan for over 1000 materials/year
DSA for EUV contact rectification, Roel Gronheid

• Grapho-epitaxy based on homo-polymer blends works, but only to maintain the relative CDU performance in combination with shrink
• Grapho-epitaxy based on BCP requires very large initial hole CD and may not be attractive path for dense hole patterns
• Chemo-epitaxy DSA flow with BCP looks promising, but does not yet meet requirements
  – Repair is not perfect
  – Some pitches and geometries don’t work well

**GRAPHO-EPITAXY WITH BCP**

<table>
<thead>
<tr>
<th>SEM image</th>
<th>Pst-Litho</th>
<th>Pst-HardBake</th>
<th>Pst-DSA + Wet Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD (nm)</td>
<td>53.8</td>
<td>58.9</td>
<td>14.5</td>
</tr>
<tr>
<td>Change (nm, %)</td>
<td>--</td>
<td>+5.1, +9.5%</td>
<td>-44.4, -75.4%</td>
</tr>
<tr>
<td>Net Shrink (nm, %)</td>
<td>--</td>
<td>--</td>
<td>-39.3, -73.0%</td>
</tr>
<tr>
<td>CD Range (nm)</td>
<td>3.4</td>
<td>3.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>
DSA is a complementary lithography technique that could be inserted as early as the 14nm node
- In a first step by using PS-\(b\)-PMMA like materials (lowest CD after etching 10nm)
- In a second step by using high \(\chi\) materials (CD < 10nm)
# Feb 2013 Outgas tool status & capacity

<table>
<thead>
<tr>
<th>Status</th>
<th>Tested as of Oct 2012</th>
<th>Tested to date</th>
<th>Current Throughput (samples per month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROX Up and running</td>
<td>53</td>
<td>81</td>
<td>8 → 24</td>
</tr>
<tr>
<td>EUVT August delivery, working towards Q4 certification &amp; customer availability</td>
<td>0</td>
<td>3</td>
<td>40 - 80</td>
</tr>
<tr>
<td>NIST Certified Aug/Sept 2011</td>
<td>9</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>EIDEC (LTJ) Certification complete, ready to start</td>
<td>0</td>
<td>60</td>
<td>30 - 40</td>
</tr>
<tr>
<td>IMEC Recently certified</td>
<td>10</td>
<td>69</td>
<td>~20</td>
</tr>
<tr>
<td>LTJ – 3 private Certified</td>
<td>no data</td>
<td>no data</td>
<td>no data</td>
</tr>
<tr>
<td>Total number of Customer samples tested</td>
<td>62</td>
<td>234</td>
<td>~70</td>
</tr>
<tr>
<td>Projected Total Capacity</td>
<td></td>
<td></td>
<td>145</td>
</tr>
</tbody>
</table>

Industry request: 250 per month, same as MET tools
## Tool status

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Total passing</th>
<th>% passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIST</td>
<td>21</td>
<td>21</td>
<td>100%</td>
</tr>
<tr>
<td>EIDEC</td>
<td>60</td>
<td>48</td>
<td>80%</td>
</tr>
<tr>
<td>ROX</td>
<td>80</td>
<td>45</td>
<td>55%</td>
</tr>
<tr>
<td>IMEC</td>
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<td>48</td>
<td>70%</td>
</tr>
<tr>
<td>EUVT</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Summary

• Comparison between outgas tools: Some samples passing at one site but failing at another
  – Request failing sample testing at multiple sites
  – Follow up by e-mail with material suppliers and consortium testing facilities

• Non-cleanables
  – 100% passing
  – Is this useful?

• RGA comparison
  – Is there a way to implement
  – Suggestion: screen with RGA, and only witness test samples that are on the borderline