EUV resist outgassing activity at Selete

Selete
Semiconductor Leading Edge Technologies, Inc.
Toshiro Itani
Outline

- Evaluation tools and methods
- Present activities and results
- Summary
- Future Plans
- Acknowledgement
Evaluation tool 1

Pressure rise method

QMS analysis

EUV Source : EQ-10MR
Power on Wafer : 0.03mW/cm²
Exposure area : 1.43 cm²
Base pressure : 8x10⁻⁷ Pa

Oct. 2nd 2008, IEUVI Optics Contamination TWG
Pressure rise method (equations)

Resist outgassing ‘RATE’ [ unit : molecules·cm⁻²·s⁻¹]

Maximum rate during exposure → indicator for exposure tool management

\[ J = \frac{\Delta p S_e}{RTA} N_A \]  
(evaluated EUV intensity)

\[ J_{400} = \frac{\Delta p S_e}{RTA} N_A \frac{400}{I} \]  
(400mW·cm⁻² assumed)

Resist outgassing ‘AMOUNT’ [ unit : molecules·cm⁻²]

AMOUNT dependence on exposure dose → indicator for resist improvement

\[ N_D = \sum_{i=0}^{t} \frac{\Delta P_i S_e}{RTA} (t_{i+1} - t_i) N_A \]

Rate and amount calculations based on the pressure variations.
**Evaluation tool 2**

**GC-MS method**

- EUV source
- Multilayer mirror
- Exposure Chamber
- QMS
- Cold-trap box
- Cryostat
- Exposure chamber
- Heating chamber
- Desorption tube
- N$_2$ Gas

**Equipment Specifications**

- **EUV Source**: EQ-10MR
- **Power on Wafer**: 0.014 mW/cm$^2$
- **Exposure area**: 1.69 cm$^2$
- **Base pressure**: $1 \times 10^{-7}$ Pa

*Oct. 2nd 2008, EUVI Optics Contamination TWG*
**Resist outgassing evaluation method**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
<th>Evaluation time</th>
<th>Selete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure rise</td>
<td>□ Simple and quick for quantitative analysis.</td>
<td>2 hours/sample</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>■ Component identification not possible.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC-MS</td>
<td>□ Component identification possible.</td>
<td>1 day/sample</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>■ CO₂ cannot be detected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Low throughput.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QMS</td>
<td>□ In-situ qualitative analysis possible</td>
<td>2 hours/sample</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>■ Quantitative analysis not possible.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Qualitative analysis inaccuracy due to fragmentation effect.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witness mirror</td>
<td>□ Contamination level directly observed.</td>
<td>A few days/sample</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>■ Low throughput and high cost.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pressure rise, GC-MS and QMS methods are applied for resist outgassing evaluations.
Outline

- Evaluation tools and methods
- Present activities and results
- Summary
- Future Plans
- Acknowledgement
More than 120 samples analyzed for resist outgassing rate.
Quantification 2

Pressure rise method for Quantification by AMOUNT

More than 120 samples analyzed for resist outgassing amount.

Oct. 2nd 2008, I EUVI Optics Contamination TWG
- GC-MS effective for component analysis. CO₂ cannot be detected.
- Fragmentation in QMS cause large difference in detected spectra.
QMS analysis for Reaction mechanisms

Dependence of component peak positions observed.

$\text{CO}_2 \ (m/z=44)$ dependent, $\text{C}_6\text{H}_5 \ (m/z=77)$ not dependent.

Oct. 2nd 2008, I EUVI Optics Contamination TWG
<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantification (Quick Screening)</td>
<td>Pressure rise method</td>
<td>Screening of resist samples received prior to exposure.</td>
</tr>
<tr>
<td>Component analysis</td>
<td>GC-MS method</td>
<td>Improvement of resist samples based on new resist components.</td>
</tr>
<tr>
<td>Mechanism analysis</td>
<td>QMS analysis</td>
<td>Basic study to improve tools and control methods.</td>
</tr>
<tr>
<td></td>
<td>GC-MS method</td>
<td></td>
</tr>
</tbody>
</table>
Quantification (Quick Screening)
Resist outgassing rate and amount evaluations were performed for more than 120 samples using the pressure rise method, prior to exposure.

Component analysis
GC-MS effective and accurate in the analysis of resist outgassing components. (CO₂ cannot be detected).

Mechanism analysis
QMS is highly recommended for component reaction mechanism analysis during exposure. GC-MS method is also applied to provide more accurate component identification for mechanism analysis.

Selete applies resist outgassing methods depending on the analysis objectives.
Future plans

- Further improvement of analysis result accuracy.
- **Discussion** with exposure tool makers (Nikon and Canon) underway.
- Establish specific resist outgassing limits for **pre-production** level.
- **Collaboration** with other research consortia, tool and material suppliers, universities and research groups.

Acknowledgement

- A part of this work is supported by New Energy and Industrial Technology Development Organization (NEDO).
- Selete member companies (EUV Lithomask program).