UPDATE ON EUV OUTGASSING
IMEC

I. POLLENTIER
Status of resist outgassing qualification for NXE3100

Investigation of outgassing and contamination in multilayer schemes
STATUS ON RESIST OUTGAS QUALIFICATION FOR NXE3100

I. POLLENTIER, AND R. LOKASANI
Outgassing qualification for NXE3100 Status March’11

Essential hardware modifications done on imec outgassing tool (vacuum improvement + e-gun)
ASML first guidelines available
System used for ADT qualifications
Work on datapackages started only in early May
## Outgassing Qualification for NXE3100

### Data Package | Data Description
---|---
1 Facilities | a. Specification resist processing (uniformity and repro)  
b. Specification ellipsometer  
c. Ellipsometry C or SiO2 on Si sample (fixed thickness cross ref)  
d. Ellipsometry Si/Ru/C peak sample  
e. Specification XPS  
f. XPS 3-layer sample (SiN/TiN/SiN)  
g. XPS Si/Ru/cleaned contamination ASML reference sample
2 Vacuum | a. RGA spectrum of ultra clean vacuum with pressure reading  
b. Pumping speed data of calibration mixture  
Functionality | a. Witness sample e-beam stability data  
b. Wafer e-beam or photon stability data
3 Cleaning | a. Cleaning process conditions  
b. Sample temperature profile as a result of duty cycle  
c. Cleaning background contribution
4 Qualification Tests | a. Contrast curve of specified resist to determine D2C  
b. D2C exposure W2W reproducibility  
c. D2C exposure within wafer uniformity  
d. Exposed area and test timing contamination growth test  
e. Reproducibility of contamination growth exposure  
f. Contamination grown from background (total thickness)  
g. Contamination grown from background (content)
5 Calibration | a. Check outgassing limited contamination growth (bleeding tests)  
b. Calibration exposures (4 resists preferred)

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Where are we?
## Outgassing Qualification for NXE3100

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I"WS are measured by 200mm tools by pocket wafers
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<td>Pumping speed data of calibration mixture</td>
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<tr>
<td>3</td>
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<td>5</td>
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</tr>
<tr>
<td></td>
<td>Calibration exposures (4 resists preferred)</td>
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</tbody>
</table>

Dose-to-clear done in 2 ways:

- **Incr. time @** const int.
- **Incr. int. @** const speed

\[ i_0 = 0.1 \times E_0 \]
## Outgassing Qualification for NXE3100

**1 Grow contamination**

**2 Measure contamination film thickness**

**3 Clean contamination**

**4 Measure non-cleaned contamination**

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**ASML spec on wafer exposure area**: >90% of 200mm wfr (>270cm2) during 1 hr

**Exposure at E0**

- 200mm wfr
- Max. scan area on imec EUVVT
- 2 wafers will be exposed, each with area ~200cm2 during ½ hr (total ~400cm2 in 1 hr)
- Delay between wafers is estimated to be <45 min, but during this time the power intensity can be adjusted.

Remaining CG tests are prepared and ongoing but need verification with WS precleaning.
Outgassing qualification for NXE 3100

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WS H-cleaner currently developed by EUV Technology will be shipped in December '11
EUV OUTGASSING AND CONTAMINATION IN MULTILAYER MATERIAL SCHEMES (EUVL POSTER)

I. Pollentier, V. Truffert, R. Lokasani, and R. Gronheid
EUV stack can be a complex stack of organic (outgassing) materials.

So far the resist is the main material to be qualified (ASML WS test), and this without presence of other layers.

In this work some layer combinations are characterized by WS test. **However emphasis was put on RGA since this enables additional understanding on mechanisms!**
**IMPACT OF LAYERS BELOW RESIST**

- **Case 1**
  - EUV resist
  - SoL

- **Case 2**
  - UL
  - SoL

- **Experimental**
  - SoL
    - 1x: SOG (Nissan)
  - UL
    - 1x: Brewer AL412
  - EUV resist
    - 4x: 3 model resists FujiFilm + SEVR140

*How much outgassing contamination can be expected from SoL when it is covered with resist?*

*Is resist outgassing changed by underlying material?*

*How efficient is an UL for suppression of outgassing & contamination of underlying SoL?*
Resist outgassing amount is (slightly) changed
A small amount of SOG related outgassing is observed
# Impact of Layers Below Resist

<table>
<thead>
<tr>
<th>Resist</th>
<th>( T_g ) (°C)</th>
<th>MW</th>
<th>Block. Ratio</th>
<th>Resist outgassing change</th>
<th>Transmitted SoL outgassing</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF Resist1</td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>-28%</td>
<td>13%</td>
</tr>
<tr>
<td>FF Resist2</td>
<td>low</td>
<td>low</td>
<td>high</td>
<td>-18%</td>
<td>33%</td>
</tr>
<tr>
<td>FF Resist3</td>
<td>medium</td>
<td>low</td>
<td>low</td>
<td>-29%</td>
<td>27%</td>
</tr>
<tr>
<td>SEVR140</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12%</td>
<td>17%</td>
</tr>
</tbody>
</table>

*resist chemistry*  
*RGA outgassing*

The transmitted SoL outgassing is related to the resist chemistry, but in line with PAG related outgassing!
## Impact of Layers Below Resist

* Using initial e-gun method (1 wafer at higher dose)

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<th>Resist</th>
<th>T_g (^°C)</th>
<th>MW</th>
<th>Block. Ratio</th>
<th>Resist outgassing change</th>
<th>SoL transmission</th>
<th>WS cont. thickness * (nm)</th>
<th>WS cont. thickness stack *</th>
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<tbody>
<tr>
<td>FF Resist1</td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>-28%</td>
<td>13%</td>
<td>0.40</td>
<td>-</td>
</tr>
<tr>
<td>FF Resist2</td>
<td>low</td>
<td>low</td>
<td>high</td>
<td>-18%</td>
<td>33%</td>
<td>1.38</td>
<td>-</td>
</tr>
<tr>
<td>FF Resist3</td>
<td>medium</td>
<td>low</td>
<td>low</td>
<td>-29%</td>
<td>27%</td>
<td>0.83</td>
<td>0.84</td>
</tr>
<tr>
<td>SEVR140</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12%</td>
<td>17%</td>
<td>0.75</td>
<td>0.85</td>
</tr>
</tbody>
</table>

*Using initial e-gun method (1 wafer at higher dose)*

WS contamination can be slightly changed by underlying SoL stack, but it is believed that this is not because of SoL related outgassing but only by change in resist related outgassing.

### Resist Chemistry

* RGA outgassing

### WS Contamination

SOG Nissan (60nm) Resist (60nm)
IMPACT OF LAYERS BELOW RESIST

Only minor fraction (~20%) and low AMU part of SOG outgassing is measured in stack.
Contamination of UL and SoL is very low, so minor risk is expected from combined stack.

* Using initial e-gun method (1 wafer at higher dose)
**Impact of Layers Above Resist**

<table>
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<th>Layer Stack</th>
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<tbody>
<tr>
<td>Substrate</td>
</tr>
<tr>
<td>Underlayer</td>
</tr>
<tr>
<td>Spin-on Layer(s) (SoL) for patterning, e.g. SOG/SOC</td>
</tr>
<tr>
<td>EUV resist</td>
</tr>
<tr>
<td>Topcoat</td>
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**Question:**

*How efficient is a topcoat for suppression of outgassing & contamination of underlying resist? Is a topcoat resulting in contamination?*

**Experimental**

- **EUV resist**
  - 4x:
    - 3 model resists FujiFilm
    - SEVR140

- **Topcoat**
  - 2x:
    - Nissan
IMPACT OF LAYERS ABOVE RESIST

Only very minor fraction and low AMU part of resist outgassing is measured in stack contamination?

Topcoat only

TC Nissan(30nm)

Resist3 (60nm)

Topcoat only

Resist3 FF only

Topcoat (Nissan) + Resist3 FF

from TC from resist

Transmitted resist (compared to resist only)
IMPACT OF LAYERS ABOVE RESIST TOPCOAT

Investigated TC’s are very effective in reducing both outgassing and contamination !!!

* Using initial e-gun method (1 wafer at higher dose)
This investigation confirms that resist is the main contributor to outgassing and contamination.

However the resist related outgassing and contamination can be slightly changed by the presence of an underlying layer.

In general, top layers are good high-amu filters for outgassing of underlying layers.

Low outgas top-coats can be very effective in reducing the resist related contamination.
ACKNOWLEDGEMENTS

N. Harned, C. Kaya, J. Steinhoff (ASML), E. Hendrickx, G. Vandenberghe, and K. Ronse (imec) for discussion and support in NXE outgas qualification.

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