Update of Resist Outgas Testing at EIDEC

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Basic Infrastructures at EIDEC

Standard Outgas Testers for Traditional Resist

**EB-based Tool**
EUVOM-9000 (LTJ)

**EUV-based Tool**
HERC (Univ. of Hyogo)

Outgas Testing in Hydrogen

Contamination Growth

Cleanable Contamination Analysis

Hydrogen Cleaning

Non-cleanable Contamination Analysis

HPEUV Irradiation Tool
(Litho Tech Japan, Gigaphoton)

Spectroscopic Ellipsometer
M-2000X (J.A.Woollam)

Atomic Hydrogen Cleaner
(EUVT)

XPS
Versa Probe II
(ULVAC PHI)
Update of Resist Outgas Testing at EIDEC

- EIDEC has continued the outgas qualification tests for commercial resists by EB-based tester, EUVOM-9000 and 475 commercial resists have been evaluated up to the present.

- Fundamental study of outgassing from organic metal complex at HERC showed the other kind of outgassing without hydrogen environment.

- EIDEC had prepared the test setup for non-CAR outgas testing at HPEUV irradiation tool in 2015/Q3.

- EIDEC has started the outgas testing in hydrogen collaborating with ASML from 2015/Q4.

- Outgas testing using pure metal oxide was carried out in hydrogen by HPEUV tool.
Concerns of Non-CAR Outgassing in Hydrogen

- Hydrogen radicals react with the metal elements in Non-CAR?
- Metal hydrides outgas from the resist?
- Metal hydride outgas species deposit on EUV mirror?

- Outgas testing using *Model Metal Materials*

- Fundamental studies without hydrogen by HERC (Poster: 9776-89)
- Outgas testing in hydrogen by HPEUV tool
Key Items for Non-CAR Outgas Testing

<table>
<thead>
<tr>
<th>EIDEC Tester</th>
<th>HPEUV</th>
<th>HERC</th>
<th>EUVOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source for resist</td>
<td>EUV</td>
<td>EUV</td>
<td>EB</td>
</tr>
<tr>
<td>Source for witness Sample</td>
<td>EUV</td>
<td>EUV</td>
<td>EB</td>
</tr>
<tr>
<td>Hydrogen environment</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Multiple wafer exposures</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

• HPEUV tool satisfies key items for non-CAR outgas testing including hydrogen environment.
• HPEUV had started the outgas testing in hydrogen environment from the end of September, 2015.
Operating Status of HPEUV Tool

Exposed Wafers counted by the standard outgas test procedure*

* Converted to exposure condition of EIDEC model CAR (5mJ/cm², 300mm wafer area)

- Nearly **1800 wafers** of the standard outgas test procedure equivalency were exposed by HPEUV tool **in the last 6 months**.
Pure Metal Oxide Outgassing by HPEUV (1)

- Pure metal oxide were prepared as model materials for outgas testing in hydrogen.
- There were no significant contamination observed by standard outgas testing by EUVOM; E0, 300mm wafer area.

Revised test conditions:

Outgas Tester : HPEUV irradiation tool
Test Material : SnO\(_2\) (100nm Sputtered)
Wafer exposure : EUV
WS exposure : EUV
Exposure dose : 360 J/cm\(^2\)
Exposed area : 8mm \(\phi\) (0.1% of 300 mm wafer)
Hydrogen : 100 Pa / no

\[\rightarrow 300\text{mJ/cm}^2, 300\text{mm wafer area equivalent}\]

- It was difficult to detect the metal outgassing due to its very small amount of outgassing.
• No significant difference between in hydrogen and in vacuum were observed for CG and RGA.
Pure Metal Oxide Outgassing by HPEUV (3)

XPS spectrum Sn3d before Hydrogen Cleaning

- Metal contamination was observed in only hydrogen environment.
• Metal contamination was remaining after hydrogen cleaning.
Pure Metal Oxide Outgassing by HPEUV (4’)

XPS spectrum Sn3d

Before/after Hydrogen Cleaning

- Metal contamination was hardly cleaned by hydrogen cleaning.
XPS mapping after cleaning

• Sn contamination was detected only on exposed area.
Summary: Metal Outgassing in Hydrogen

- It was difficult to detect the metal outgassing due to its very small amount of outgassing.
- However it is possible to evaluate resist outgassing in hydrogen by HPEUV tool.
- Expected outgassing phenomenon for some metals are,
  - Outgassing is very small amount.
    (→ Very high EUV exposure dose is needed to evaluate.)
  - Outgassing generates only in hydrogen.
  - Contamination is hardly cleaned by hydrogen cleaning.
  - Contamination generates only on exposed area.
- Don’t jump to a hasty conclusion! Outgas amount may be very small and Outgassing at actual dose region is still unknown.
- More detail outgas research is needed to predict the actual impact to the scanner.
February 23, Tuesday: Poster Session:

- E. Shiobara, et al., “EUV resist outgassing analysis for the new platform resist at EIDEC” (9776-89)
  - Fundamental study by HERC using organic-metal complex
  - The other kind of outgassing without hydrogen was found

- S. Mikami, et al., “High-power EUV irradiation tool setup for resist outgas evaluation in hydrogen” (9776-91)
  - Details of outgas testing in hydrogen by HPEUV tool
Acknowledgement

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Thank you!