IEUVI Resist TWG

Nov. 10th, 2005

Brief Regional Update: MEDEA

M. Goethals, W.-D. Domke
EUV Resist Technology Cooperation in ExCITE project

Peter Zandbergen **
Koen van Ingen Schenau

PHILIPS

Harun Solak
Kurt Ronse

Jean-Yves Robic

imec

Italy: Carmelo Romeo
France: Daniel Henry

Michele Bertolo

CEA LETI

Infineon technologies

Wolf-Dieter Domke *

Harun Solak

Italy: Carmelo Romeo
France: Daniel Henry

Karl van Werden

Enzo Di Fabrizio

*) Work Package 1 Leader
**) MEDEA+ T406 Project Leader

ExCITE T406 – WP 1 - EUV Resist Technology

IEUVI Resist TWG
Status Nov 2005
The EXCITE project aims at developing Extreme Ultra-Violet (EUV) imaging capability for the 45nm technology node and beyond.

Approach is to address bottlenecks related to EUV lithography imaging for implementing full-field patterning development.

Three year program, ending Dec 31, 2005.
Exposure Tools

- the BEL tool is in the stage of upgrading & debugging

- ASML a-tool is on schedule

- PSI Zurich interferometer is operational:
  - available for others; pay per shift
  - reliably working
  - used by european projects and others
  - good aerial image/flare conditions
  - 35nm dense lines (by XSEM) achieved in CA
  - showed good matching with ALS/MET results
EUV resist resolution in PMMA

EUV Interference lithography

25 nm L/S
21.25 nm
17.5 nm
15 nm
EUV resist resolution in PMMA
EUV Interference lithography

50 nm half pitch
45 nm
40 nm
35 nm
30 nm
The most promising samples from the vendors have been evaluated in several exposure rounds by EUV interference and projection optics lithography.

- **state-of-the-art CA resists resolve down to 32.5 nm**
- **CAR performance is material-limited, not tool-limited**
- Resist trends in LER, process windows and ultimate resolution seem to correlate well between PSI and the MET but not for the profiles.
- „High flare“-conditions put a considerable challenge on the resists, resulting in lower exposure latitude, higher roughness, more resist-loss at slight overexposure, more footing and scumming.
“Resist and Process Limitations“ reported

- The top three of most critical issues are related to the ‘lithographic uncertainty principle’, stating that resolution, line edge roughness (LER) and sensitivity of photoresists are fundamentally linked.

- Theoretical model describes experimental data taken at various pitches and different lithographic techniques (ArF & EUV).

- Resists can be optimized for LER by tuning the acid diffusion length to 1/3 of the pitch; but for a given dose, EL and LER cannot be optimized simultaneously.

Measured contrast (EL) divided by NILS – to filter out differences in optical contrast – is used to quantify the impact of acid diffusion on contrast.
"Resist and Process Limitations" reported

Two distinct regions visible:

- $L_d / \text{pitch} < 0.33$: improvement of deprotection statistics due to acid diffusion prevails, reducing overall line edge roughness
- $L_d / \text{pitch} > 0.33$: chemical contrast drop due to diffusion takes the lead and causes LER to increase

Scaling of LER with $L_d$:

\[
LER_{\text{corr, dose}} \propto \left( \frac{1}{L_d} \right)^{3/2} / MTF_{\text{diff}} \left( \frac{L_d}{P} \right)
\]
Outlook - Summary

- EXCITE project (phase 1) will close by end of December 2005
- Project approach (resist WP) was to address bottlenecks related to EUV imaging
  - investigate resist platforms on small field tools
  - investigate resist issues such as LER, diffusion, outgassing, ...
- The most important challenges of resist development for the 32 and 22nm node have been identified; this includes EUV specific and general CA-resist issues.
- We feel that projects should be started to stretch the limits of available CA-resist platforms to the 32nm node, while other projects should target at new material options for the 22nm node.
**Recent Results**

Chemically amplified resist

<table>
<thead>
<tr>
<th></th>
<th>EUV-6</th>
<th>EUV-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{\text{size}}$</td>
<td>11mJ/cm$^2$</td>
<td>7.5mJ/cm$^2$</td>
</tr>
<tr>
<td>Exp. Lat. (50nm)</td>
<td>18%</td>
<td>11%</td>
</tr>
<tr>
<td>LER (3$\sigma$)</td>
<td>7.1nm</td>
<td>5.7nm</td>
</tr>
<tr>
<td>Resolution</td>
<td>32.5nm</td>
<td>32.5nm</td>
</tr>
</tbody>
</table>

**EUV-25:** $E_{\text{size}} \sim 7.5\text{mJ/cm}^2$