Recent Progress on High-Brightness Source Collector Module for EUV Mask Metrology

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NewLambda Technologies

• Spin out from UCD School of Physics, Ireland
• Developing VUV, EUV and Soft X-ray sources
• Applications
  – Metrology
  – Table-top tuneable beamline
  – Microscopy
Metrology Source Considerations

<table>
<thead>
<tr>
<th>Tool Requirements*</th>
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</thead>
<tbody>
<tr>
<td>Metrology Tool</td>
</tr>
<tr>
<td>AIMS</td>
</tr>
<tr>
<td>Mask Blank</td>
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<tr>
<td>Patterned Mask</td>
</tr>
</tbody>
</table>

Choices for etendue matching:

- Demagnify large source – photon loss for fixed etendue
- Magnify small source - higher photon collection
  - higher brightness for given input power

Magnifying ellipsoid (x8)
Placed < 20 mm from EUV Source
Etendue ≥ 10^-4 mm^2sr
High Brightness
## Mask Metrology SoCoMo Status

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Industry Target Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIMS</td>
</tr>
<tr>
<td>Brightness (W/mm²sr)</td>
<td>30-100</td>
</tr>
<tr>
<td>Etendue (mm²sr)</td>
<td>5e-4</td>
</tr>
<tr>
<td>Position Stability (of FWHM)</td>
<td>3%</td>
</tr>
<tr>
<td>Size Stability</td>
<td>3%</td>
</tr>
<tr>
<td>Energy Stability</td>
<td>&lt;3%</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Operating time</td>
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* EUVL Symposium, 2011
NLT Source

• LPP (Nd:YAG 125W, 25 mJ per pulse, 5 kHz)
• Proprietary liquid metal mixture as target
• Current status:
  – >200 hours total operation (since Nov. 2011)
  – Brightness = 80 W/mm²sr
    • (Brightness calculated using the Carl Zeiss method)
  – 24 hours continuous
  – Self-healing collector
  – Roadmap to >500 W/mm²sr, 100 hours continuous
Source Imaging

• Imaged using multilayer concave mirror
• 10 shots per frame
• 34 x 55 micron spot measured
• Gaussian fit
Source Imaging

![Diagram showing the relationship between laser spot radius, laser energy (mJ), and plasma diameter (microns).]
Source Spectra

- Nd:YAG, 17 mJ per pulse, 1 kHz
- Viewed at 45°
- CE > 1% measured
Stability - Source Position

Imaged with 50 µm pinhole

σ = 0.3 %

Δ FWHM (%)

Run Number
Collector design example:
Tin-based coating
Ellipsoid Shape
Length = 100 mm
Large Diameter = 40 mm
Predicted Collection ~ 3%

Optimising:
Collection efficiency
IF brightness
Intermediate Focus Imaging

- Single Shot Imaging
- Lorentzian fit
- IF spot size 250 x 400 microns
IF Stability

Position
• Measured $\sigma = 7\%$
• Required $\sigma = 3\%$

Size
• Measured $\sigma = 8\%$
• Required $\sigma = 3\%$
NLT SoCoMo

- High Brightness LPP
- Clean IF
- Stand Alone Unit
- 1 m x 1 m x 1.2 m
- Multiple parameter monitoring
## Mask Metrology SoCoMo Status

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Future Plans

• Upgrade Laser to 300 W
• Improve source stability
• Optimising Liquid Metal recipe, (CE & Reflectivity)
• Extend Lifetime operation
We would like to acknowledge the kind support of Regina Soufli, Lawrence Livermore National Laboratory, also Larissa Juschkin, RWTH Aachen, EUVLitho and the technical workshop at the UCD School of Physics

Thank you for listening