Printing results from a multi-beam mask exposure tool

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Vienna, Austria

Sept 11, 2012, Monterey Marriott
Proof-of-Concept electron Mask Exposure Tool

\textbf{eMET POC}

- Column designed for 11nm HP (8nm logic) node
- Column extendibility to 8nm HP and 6nm HP nodes

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eMET Column with 262,144 programmable beams

**at APS (Aperture Plate System)**

- **Aperture**: 4µm x 4µm
- **Cell Size**: 32µm x 32µm
- **# Cells**: 512 x 512
- **# Apertures**: 262,144

**at 6" Mask Blank**

- **Beam Size**: 20nm x 20nm
- **Cell Size**: 160nm x 160nm
- **# Cells**: 512 x 512
- **# Beams**: 262,144
Stationary Stage & Scanning Stripe Multi-Beam Exposure

Stationary Stage Write Mode
Beam array deflected by multipoles
Purpose: debugging, calibration
Exposure of 82µm square region

Scanning Stripe Write Mode
Beam array deflected ±160nm
Stage at constant velocity
Exposure of 82µm wide stripes
Multi-Beam Writing Modes with Overlapping Shots

MESA
Multiple Exposure Shot Addressing

DOUBLE Grid
Pixel Size = \( \frac{1}{2} \) Beam Size

QUAD Grid
Pixel Size = \( \frac{1}{4} \) Beam Size

Each spot exposed with 4bit: 16 dose levels (0, 1, 2, ..., 15)
MESA with QUAD Grid

- Every 20nm shot exposed with 4bit = 16 dose levels (0, 1, 2,...,15)

- MESA – Multiple Exposure Shot Addressing

**QUAD Grid:**

- Beam Size: 20 nm
- Pixel Size: 5 nm

=>

16 x 15 + 1: 241 dose levels / area
4 x 15 + 1: 61 dose levels / edge
Multi-Beam Writing with 0.1nm Address Grid

\[ y = 0.9919x + 0.7075 \]

\[ R^2 = 0.9993 \]
Multi-Beam Writing with 0.1nm Address Grid

101.3 x 7 = 709.1nm

109.8 x 6 + 50 = 708.8nm
eMET POC exposure with 256k-APS

ILT device test pattern

<table>
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<tr>
<th>Scanning Stripe exposure</th>
<th>20nm beam size</th>
<th>5nm pixel size</th>
<th>with PEC</th>
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ILT device test pattern
Design: DNP

POC01_201_pos69_mechrot, 1k, 2kV, WD4

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### eMET POC exposure with 256k-APS

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![Image of ILT device test pattern](image.jpg)

POC01_201_pos69_cert_mechrot, 4k, 2kV, WD4

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POC01_201_pos69_mechrot, 1k, 2kV, WD4

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eBeam Initiative Meeting
eMET POC exposure with 256k-APS

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exposure of DNP design

exposure 2-times smaller

60nm dots

30nm dots

Design
### eMET Schedule

<table>
<thead>
<tr>
<th></th>
<th>POC</th>
<th>ALPHA</th>
<th>BETA</th>
<th>1st gen. HVM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2012</strong></td>
<td>2014</td>
<td>2015</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td><strong>Technology Node</strong></td>
<td>Test: 11nm HP (8nm Logic)</td>
<td>11nm HP (8nm Logic)</td>
<td>11nm HP (8nm Logic)</td>
<td>11nm HP (8nm Logic)</td>
</tr>
<tr>
<td><strong>Data Path &amp; APS Speed</strong></td>
<td>12.8 Gbits/s</td>
<td>12.8 Gbits/s</td>
<td>120 Gbits/s</td>
<td>120 Gbits/s</td>
</tr>
<tr>
<td><strong>Beam Array Field</strong></td>
<td>82µm x 82µm</td>
<td>82µm x 82µm</td>
<td>82µm x 82µm</td>
<td>82µm x 82µm</td>
</tr>
<tr>
<td><strong>max Current Density</strong></td>
<td>1 A/cm²</td>
<td>1 A/cm²</td>
<td>1 - 4 A/cm²</td>
<td>1 - 4 A/cm²</td>
</tr>
<tr>
<td><strong># Beams</strong> (k=1024)</td>
<td>256k</td>
<td>256k</td>
<td>256k</td>
<td>256k</td>
</tr>
<tr>
<td><strong>Beam Size</strong></td>
<td>20nm</td>
<td>20nm</td>
<td>20nm - 10nm</td>
<td>20nm - 10nm</td>
</tr>
<tr>
<td><strong>max Current</strong> (all beams “on”)</td>
<td>1 µA</td>
<td>1 µA</td>
<td>1 µA</td>
<td>1 µA</td>
</tr>
<tr>
<td><strong>Throughput</strong> (≥ 100µC/cm²)</td>
<td>10 cm²/h</td>
<td>15h / mask</td>
<td>10h / mask</td>
<td>10h / mask</td>
</tr>
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</table>
Thank You for Your Attention!

**Synopsys - IMS poster presentation**
Tuesday, 6:00pm - 7:30pm
[8522-87]

**IMS oral presentation**
Thursday, Session 12, 11:00am - 11:20am
[8522-52]

40nm HP Metal

30nm HP 0°,45°,90° L&S

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