Welcome to 2010 SPIE Lunch

Aki Fujimura
CEO – D2S, Inc.
Managing Sponsor – eBeam Initiative
Summary of Today’s News

• eBeam Initiative grows to 27 members

• Design for E-Beam (DFEB) Mask Technology Launched
  – 22nm logic and beyond
  – High-volume applications

• PMJ papers to be presented in April by Initiative members
Welcome to the New Members
Today’s Agenda

Samsung Viewpoint

Dr. Seong-Sue Kim, Principal Engineer, Photomask Team – Samsung Member – eBeam Initiative

Industry Need for DFEB Mask Technology

Aki Fujimura, CEO – D2S, Inc. Managing Sponsor – eBeam Initiative

Toppan Viewpoint

Dr. Franklin Kalk, Executive Vice President and CTO – Toppan Photomasks, Inc. Member – eBeam Initiative

Q&A
Samsung Viewpoint

Dr. Seong-Sue Kim
Principal Engineer, Photomask Team – Samsung Electronics
Member – eBeam Initiative
The 22-nm Challenge:
DOF and Reduced Shot Count are Essential

DFEB Mask Is An Enabler at 22-nm

• Without DFEB mask, 193i at 22-nm forces you to choose between a good wafer (high yield) and a good mask (simple pattern).

• We must have both and DFEB mask enables that.

• Samsung collaboration on DFEB mask with eBeam Initiative members is underway.
DFEB Mask Can Extend 193i Roadmap

DFEB mask

EUV

DRAM

SoC

193i

DFEB Mask Is Also Good for EUV Masks
Industry Need for DFEB Mask Technology

Aki Fujimura
CEO – D2S, Inc.
Managing Sponsor – eBeam Initiative
DFEB Mask: Delivers Best DOF with Reduced Shot Count

Circles are Better for Design AND Manufacturing

*Violates min dist rule*

Patents pending, D2S, Inc.
Printing circles as characters

Dose provided:

<table>
<thead>
<tr>
<th>Dose (uC/cm²)</th>
<th>Shot Diameter (nm)</th>
<th>Hole Diameter on mask (measured)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>118</td>
<td>89nm, 106nm, 115nm</td>
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<tr>
<td>19.7</td>
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<td>24.3</td>
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Shot diameter = 118

Hole Diameter on mask (measured)

Shot Diameter = 142

Hole Diameter on mask (measured)

Shot Diameter = 334

Hole Diameter on mask (measured)

Courtesy JEOL, Ltd. More details at PMJ 2010

Patents pending, D₂S, Inc.
Overlapping Circles = Smooth Curvilinear Features with Fewer Shots

Target Shape

40 Conventional VSB Shots

15 Overlapping VSB Shots

13 Overlapping Circles

Patents pending, D₂S, Inc.
Overlapping Circles = Smooth Curvilinear Features with Fewer Shots

Target Shape

Shots Used

Target Shape

Simulated Mask Shape

Courtesy Luminescent, Inc.

Patents pending, D2S, Inc.
Toppan Viewpoint

Dr. Franklin Kalk
Executive Vice President and CTO – Toppan Photomasks, Inc.
Member – eBeam Initiative
The 22-nm Challenge:
Complex Mask Shapes Required

<table>
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<tr>
<th>Technology cycle</th>
<th>250nm</th>
<th>180nm</th>
<th>130nm</th>
<th>90nm</th>
<th>65nm</th>
<th>45nm</th>
<th>32nm</th>
<th>22nm</th>
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<td>Circuit design</td>
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<td>Mask design</td>
<td>OPC rule-based</td>
<td>OPC model-based</td>
<td>DE</td>
<td>DE/SMO</td>
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<td>Mask build</td>
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<td>Recommended rules</td>
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Aggressive OPC increases e-beam shot count (penalty shown is >10x).
The 22-nm Challenge:
Complexity $\Rightarrow$ Mask Write Time $\Rightarrow$ Cost

- Complex features increase shot density and mask cost
- The forecasted per-mask capital cost at 22nm is $\sim$~$60k

Mask Production Line Throughput and Cost

- Output per day
- Line capex ($M$)

Technology cycle (nm)

Line output (parts per day)

Mfg. line capital cost ($M$)
Merchant Mask Viewpoint

- EUV is likely to be too expensive for mainstream SoCs
- Extending 193i lithography is critical
- Critical layer masks should be written in 8-12 hours to be economically viable
- Mask write time for complex shapes is a critical issue

Circles and DFEB mask are good for merchant mask makers
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