Outline

• Current status
• Argument for increasing absorbance
• Implications
## Gen 2 Platform Development

<table>
<thead>
<tr>
<th>Quarter</th>
<th>YA-AA</th>
<th>YA-BA</th>
<th>YF-xx</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Q14</td>
<td>22nm HP: (\sim 90) mJ/cm(^2) (microfield exposure)</td>
<td>17nm HP: (40) mJ/cm(^2) (microfield exposure)</td>
<td>13nm HP: (35) mJ/cm(^2) (NXE:3300 scanner)</td>
</tr>
<tr>
<td>2Q14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Q14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4Q14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1Q15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2Q15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Q15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4Q15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- IMEC N7 Block Mask
  - 21nm CD, 35mJ/cm\(^2\)
  - 23nm CH, 30mJ/cm\(^2\)
Extendibility

9.5nm lines on 20nm pitch, LWR 1.8nm, ~50mJ/cm²
Resist Stability

Resist stored at room temp shows good dose stability through 6 months.
Inpria Approach: Tin Oxide Based Resist

5X smaller molecules

5X more photons absorbed / volume

10X higher etch selectivity

Required resolution & smooth lines

Path to faster photospeed at high resolution

Improved yield & simpler process

11nm half-pitch (Inpria)
Role of Resist Absorbance

High Amp Req’d!

Absorption Coefficient (1/μm)

Resist Thickness (nm)

Red: abs (10%)
Blue: abs (20%)
Green: abs (35%)

EUV CA resists
Amplification: Blur & Noise

• CAR resolution limited by “blur” from amplification

• Results in tradeoff between dose and resolution

• Amplification further constrained by photon shot noise due to transparency of CA resist
Role of Resist Absorbance

Ideal absorption for <20nm resolution

High Amp Req’d!

EUV CA resists

Absorption Coefficient (1/μm)

Resist Thickness (nm)
Maximizing EUV Absorbance

EUV absorbance relative to CAR

- Inpria Sn based resists: absorbance ~20/µm (~4-5X typical CAR)
  - Dense metal oxide: minimize secondary electron blur
- Harvest photons efficiently to minimize amplification
  - Minimize amplification blur
  - Minimize impact of photon shot noise
Visualizing Photon Shot Noise

<mean photons per pixel>

0.001 0.01 0.1
1 10 100
1,000 10,000 100,000
Design in Photon Shot Noise Regime

\[ \text{PSN} \sim \frac{1}{\sqrt{N}} \]

\[ \text{Dose (mJ/cm}^2\text{)} \]

\[ \text{Relative Photon Shot Noise} \]

\[ \text{CAR (abs 4.3/\mu m)} \]

Prolith simulation: 20nm x 20nm sq, 30nm resist thickness (courtesy John Biafore, KLA-Tencor)
Design in Photon Shot Noise Regime

PSN $\sim \frac{1}{\sqrt{N}}$

Prolith simulation: 20nm x 20nm sq, 30nm resist thickness (courtesy John Biafore, KLA-Tencor)
Implications

• Metal containing resists are increasingly likely to be part of the landscape

• Implies increasing number of collaborations to manage integration issues
  – Mechanistic modeling to determine opportunities & limits in context of shot noise
  – Metrology & management of metal cross-contamination in fab
  – Metrology for trace metal content in resist in presence of primary metal
  – Scanner compatibility, particularly related to outgassing
  – Track compatibility
  – Etcher compatibility
  – CD metrology for very thin metal containing resist films

• Many collaborations will necessarily be bilateral due to confidentiality
• However, we can accelerate progress through more open requirements