The Impact of Context-Dependent Mask-Effects on Mask Hotspots

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Below 50nm, Context is Critical

- Red lines are cut lines to show dose profile
- Vary L:S = 13nm to 300nm using 30nm and 15nm blurs
- Will compare the differences of line 1 and line 10, as well as line end shortening

- Above 50nm, context-independent rules-based processing works well enough
- Below 50nm, context is critical
- If we can’t push below 40nm, we leave the benefits of Moore’s Law on the table
- Simulation-Based Mask Processing is the inevitable answer
Below 50nm, Context is Critical

Each picture is scaled up to show the contour
Below 50nm, Context is Critical For Line-End Shortening, Too
Slower Resists Do Print Much Better

30nm Blur

15nm Blur

Each picture is scaled up to show the contour
Slower Resist: Less CD Variation

30nm blur
15nm blur

40nm
30nm blur
15nm blur

50nm
30nm blur
15nm blur

70nm
30nm blur
15nm blur

100nm
30nm blur
15nm blur

300nm
30nm blur
15nm blur

1000 epoch Monte Carlo of threshold variation
But Slower Resists Have Limits, Too

Each picture is scaled up to show the contour
Dose Up for Better Contrast

15nm beam blur

Contrast
Use Simulation to Dose Up for Better Contrast

<table>
<thead>
<tr>
<th>Raw (No Correction)</th>
<th>13nm</th>
<th>15nm</th>
<th>20nm</th>
<th>25nm</th>
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A Choice Between Two Evils?

Conservative Design Rules

OR

Mask Hotspots Escape Mask Shop
Simulation is the future of MDP

- Dose-modulation based correction provides the best solutions
- Context-dependent correction is needed regardless of writing method