Double Patterning

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Options to print below immersion single exposure limit

- **Single exposure | SE 45nm**
- **Double exposure | DE 38 nm**
- **Litho DPT - LELE | LDPT 32nm**
- **Litho DPT - LFLE | LDPT 32nm**
- **Spacer DPT | SPCR 32nm**

- SiON /HM Etch
- Clean
- Strip
- Film Etch
- Metrology
- Develop
-Expose
- Top coat
- Resist
-BARC
-SiON / SiC
-Hard Mask
-Device film
-Si

*Wafer preferably does not leave the litho cell between the exposures
*Wafer leaves litho cell for etch between the exposures

Cost, complexity and cycle time
Double patterning will bridge the gap between single exposure 193 nm immersion and EUV.

Resolution, "Shrink" [nm]

Year of Production Start*

*Process development 1.5 ~ 2 years in advance (updated 12/07)
Litho cost per layer: estimates for 32 nm & 22 nm
Single exposure schemes more cost effective

Reticle cost based on 5000 wafers / mask usage
Litho double patterning data flow, 2 masks/exposures

1. **Target layout**
2. **Split 1**
3. **Coloring**
4. **Model based stitching**
5. **Model OPC**
6. **Processing Litho/etch**
7. **Combined patterns from exposures → frequency double**
8. **Final contour**
9. **Exposure 1**
10. **1st Mask**
11. **Exposure 2**
12. **2nd Mask**
13. **Split 2**
14. **Target layout**
Spacer with overlay-friendly layout
to enjoy overlay advantage from the self-aligned process

Slight gap enlargement to meet overlay requirement

Slight device enlargement to meet overlay requirement
Double patterning requires better and more lithography

<table>
<thead>
<tr>
<th>Litho exposure equipment parameter as percentage of CD</th>
<th>Single exposure</th>
<th>Litho double patterning</th>
<th>Spacer double patterning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔCD</td>
<td>7%</td>
<td>3.5%</td>
<td>3%</td>
</tr>
<tr>
<td>Overlay (depending on DFM)</td>
<td>20%</td>
<td>7%</td>
<td>7-20%*</td>
</tr>
<tr>
<td>#mask steps</td>
<td>1</td>
<td>2</td>
<td>2-3</td>
</tr>
<tr>
<td># process steps relative to single exposure</td>
<td>1</td>
<td>2</td>
<td>3-4</td>
</tr>
<tr>
<td>Application</td>
<td>2D, All</td>
<td>2D, All</td>
<td>1D, Mainly Memory</td>
</tr>
</tbody>
</table>

* Depending on the amount of “Design For Manufacturing” effort
Conclusion

To make DPT profitable ASML has to provide machines with higher productivity and better accuracy (overlay and CD)

The new NXT platform is prepared to support our customers to meet DPT challenges for the coming nodes