Objective

• Find the properties of the new photoresist:
  o Thickness
  o E0 Clear Energy
  o Find correct exposure and focus for thin and thick photoresist coating
  o Out gas check
Thicknes

- Trial 1: Spin 21 wafers 1000-5000 RPM with a proximity bake at 130 C for 30 seconds
- Trial 2: Spin 20 wafers from 850-1800 RPM and 20 wafers from 4300-5250 RPM with a proximity bake at 130 C for 30 seconds
- Use the nanospec to find the thicknesses at different locations on the wafer and take the average

What we did

What would have given a more accurate thickness

The physics of coating a wafer

The photoresist spins radially outward because of the centripetal force. The center is the thickest and the edges are the thinnest.
Spin Speed Curves

Spin Speed Curve for 1000-5000 RPM

Spin Speed Curve for Slow Spin Speeds

Spin Speed Curve for 5000-6000 RPM

Spin Speed Curve for Fast Spin Speeds

Trial 1

Trial 2
E0 Clear Energy

- Use the ASML300 stepper to expose wafers to UV light
- Use svgdev6 to develop wafers
- Trial 1: PEB at 130 C
- Trial 2: PEB at 110 C
- Find at which energy the photoresist clears. Record and graph a swing/interference curve.
Interference/Swing Curves

- Interference between outgoing and incoming light waves due to a phase difference between them will result in a swing curve.
- Path length of the light through to photoresist determines whether light interference is constructive or destructive.

http://www.phys.uconn.edu/~gibson/Notes/Section5_2/Sec5_2.htm
Interference/Swing Curves

Destructive                         Constructive
Interference/Swing Curves

- Ideal graph has a sinusoidal pattern
- Actual graphs:

![Interference Curve](image-url)
Trial 2

Interference Curve for Slow Spin Speeds (Thicker Coat)

Interference Curve for Fast Spin Speeds (Thinner Coat)
Focus/Exposure Matrix
CMOS200

• What is an FEM?
  ○ matrix that changes with energy dose and focus

• Purpose of FEM: use uvscope to find the right exposure and focus to have a clear, fully developed image

• Difficulties?
  ○ Finding the most clear image of 165 options per wafer (we examined 20 wafers)
  ○ Underexposed, overexposed, or damaged?
Post-Exposure Bake (PEB)

- What is PEB?
  - Bake after exposing the wafer to UV light
- We tested PEB at 110, 120, and 130 C (130 C is preferable)
- We found that 110 C was the best temperature for PEB.
Soft Bake (SB)

- Soft bake is the bake on svgcoat6 before the wafer is exposed to UV light in the ASML.
- Vendor recommends to have SB at 140 C. We tried the soft bakes 130 C because all programs on svgcoat6 are at 130 C. We want to avoid changing the temperature for different programs.
- We determined how long the soft bake would be at 130 C by coating 2 wafers and having soft bakes at 60 and 90 seconds.
Comparing Soft Bake at 130 C for 60 and 90 seconds

- Images on the olympus: profile view

60 seconds

90 seconds

Wafer 6A: 1.0um forks, 50343 A, SB 130C for 60 sec, PEB 110 for 60 sec, 45 mJ/cm2, focus: 2.4

Wafer 7A: 1.0um forks, 49867A, SB 130 for 90 sec, PEB 110 for 60 sec, 51 mJ/cm2, focus: 3.2
Comparing Soft Bake 130 C with 140 C at 5000 RPM, PEB at 110 C for 60 sec

**130 C**
- Wafer 8A: 1.0 um forks, 32000A, SB 130 for 90 sec, PEB 110 for 60 sec, 29 mJ/cm², focus: 2.0

**140 C**
- Wafer 11: 1.0um forks, 31854A, SB 140 C for 90 sec, PEB 110 C for 60 sec, 27mJ/cm², focus: 1.6
Comparing Soft Bakes 130 C with 140 C at 1000 RPM, PEB at 110 C for 60 sec

**Wafer 7A:** 1.0um forks, 49867A, SB 130 C for 90 sec, PEB 110 C for 60 sec, 51 mJ/cm², focus: 3.2

**Wafer 10:** 1.0 um forks, 49018A, SB 140 C for 90 sec, PEB 110 C for 60 sec, 43 mJ/cm², focus: 2.4
Comparing 140 C with 130 C at longer times, 5000 RPM $\approx 3.2\mu m$

**Wafer 11:** 1.0um forks, 31854A,
SB 140 C for 90 sec,
PEB 110 C for 60 sec, 27mJ/cm²,
focus: 1.6

**Wafer 12:** 1.0 um forks, ~32000A,
SB 130 C for 120 sec,
PEB 110 C for 60 sec, 33 mJ/cm²,
focus: 1.2
Wafer 11: 1.0um forks, 31854A, SB 140 C for 90 sec, PEB 110 C for 60 sec, 27 mJ/cm2, focus: 1.6

Wafer 13: 1.0 um forks, ~32000A, SB 130 C for 180 sec, PEB 110 C for 60 sec, 31 mJ/cm2, focus: 1.6
Wafer 11: 1.0um forks, 31854A, SB 140 C for 90 sec, PEB 110 C for 60 sec, 27mJ/cm², focus: 1.6

Wafer 14: 1.0 um forks, ~32000 um, SB 130 for 300 sec, PEB 110 for 60 sec, 29 mJ/cm², focus: 1.6
Comparing 140 C with 130 C at Longer Times, 1000 RPM ~≈4.7 um

Wafer 10: 1.0 um forks, 49018A, SB 140 C for 90 sec, PEB 110 for 60 sec, 43 mJ/cm², focus: 2.4

Wafer 15: 1.0 um forks, ~47000A, SB 130 C for 120 sec, PEB 110 C for 60 sec, 41 mJ/cm², focus: 2.8
Wafer 10: 1.0 um forks, 49018A, SB 140 C for 90 sec, PEB 110 for 60 sec, 43 mJ/cm2, focus: 2.4

Wafer 16: 1.0 um forks, ~47000A, SB 130 C for 180 sec, PEB 110 C for 60 sec, 41 mJ/cm2, focus: 2.4
Wafer 10: 1.0 um forks, 49018A, SB 140 C for 90 sec, PEB 110 for 60 sec, 43 mJ/cm², focus: 2.4

Wafer 17: 1.0 um forks, ~47000A, SB 130 C for 300 sec, PEB 110 C for 60 sec, 41 mJ/cm², focus: 2.8
Out Gas Check

- How much solvent will escape from the photoresist at different temperatures and times using the STS2?

Results:

<table>
<thead>
<tr>
<th>Wafer #</th>
<th>Without any wafer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB temp</td>
<td>140 C</td>
<td>140 C</td>
<td>140 C</td>
<td>140 C</td>
<td>130 C</td>
<td>130 C</td>
<td>130 C</td>
<td></td>
</tr>
<tr>
<td>SB time</td>
<td>60 sec</td>
<td>60 sec</td>
<td>90 sec</td>
<td>120 sec</td>
<td>60 sec</td>
<td>90 sec</td>
<td>120 sec</td>
<td></td>
</tr>
<tr>
<td>Leak Rate</td>
<td>.06 mTorr/min</td>
<td>.06 mTorr/min</td>
<td>.08 mTorr/min</td>
<td>.06 mTorr/min</td>
<td>.06 mTorr/min</td>
<td>.08 mTorr/min</td>
<td>.06 mTorr/min</td>
<td>.08 mTorr/min</td>
</tr>
</tbody>
</table>
## Conclusions

### Best Conditions

<table>
<thead>
<tr>
<th>Resist Thickness</th>
<th>Soft Bake Temperature and Time (Best CD)</th>
<th>Soft Bake Temperature and Time Alternative</th>
<th>E0 Clear Energy</th>
<th>PEB Temperature and Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>~33000 A (5000 RPM)</td>
<td>140 C for 90 seconds (CD .3 um)</td>
<td>130 C for 300 seconds</td>
<td>23 mJ/cm2</td>
<td>110 C for 60 seconds</td>
</tr>
<tr>
<td>~47000 A (1500 RPM)</td>
<td>140 C for 90 seconds (CD .7 um)</td>
<td>130 C for 300 seconds</td>
<td>26-27 mJ/cm2</td>
<td>110 C for 60 seconds</td>
</tr>
</tbody>
</table>
Acknowledgements

• Thank you Kim Chan for teaching me so much and being a great mentor.
• Thank you Jeff Clarkson for teaching me how to use many tools and helping me with my project.
• Thank you Ryan Rivers for helping me with my project.
• Thank you Marilyn Kushner for taking us to Semicon.
• Thank you Sia Parsa for advising us when our results weren’t perfect.
• Thank you Katalin Voros and Bill Flounders for providing this great opportunity.
• Thank you all staff members for being supportive of my project.