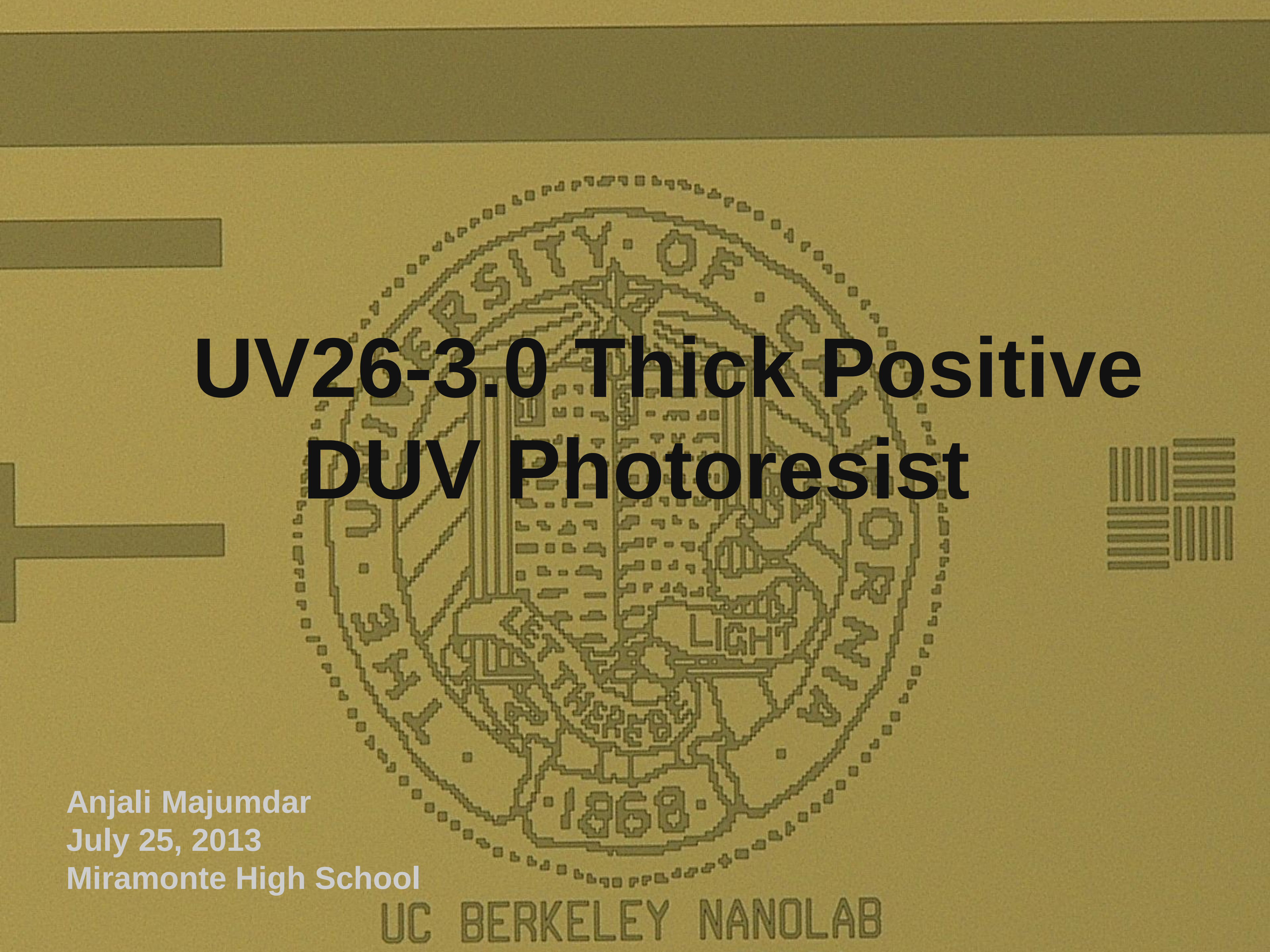
UV26-3.0 Thick Positive DUV Photoresist



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July 25, 2013
Miramonte High School

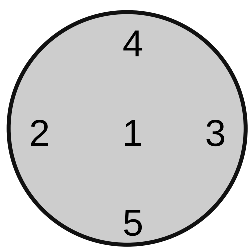
Objective

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

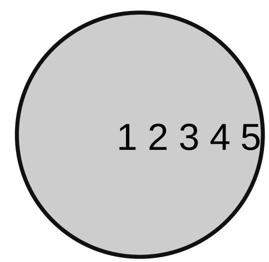
Thickness

- 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

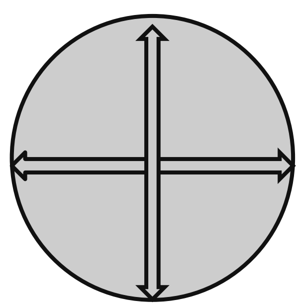
What we did



What would have given a more accurate thickness

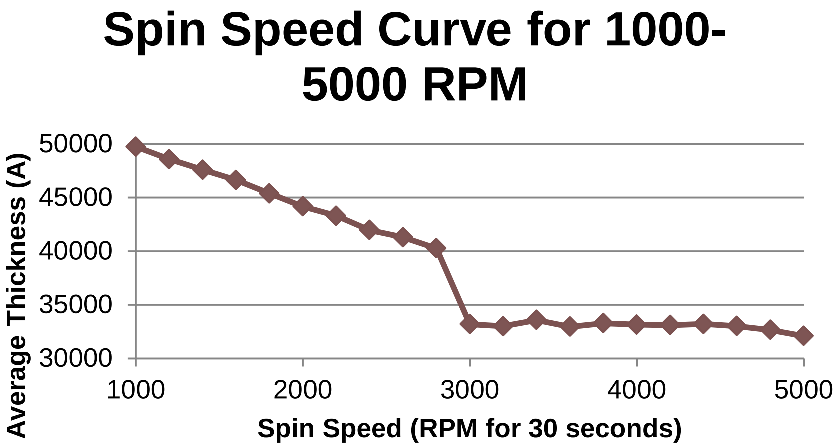


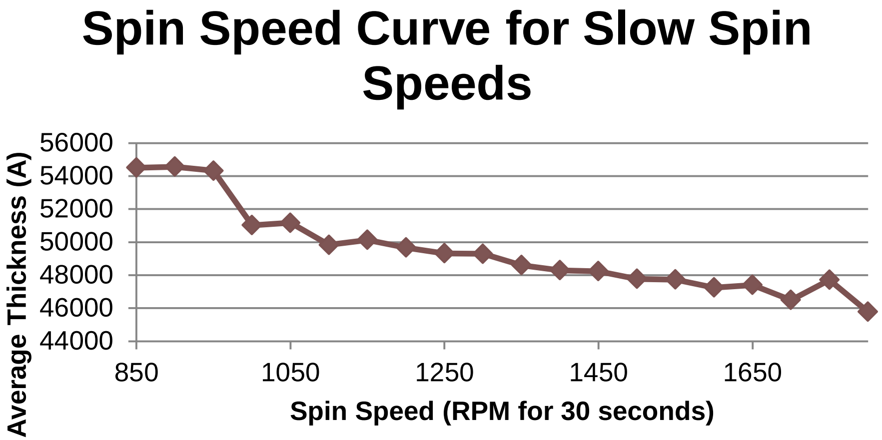
The physics of coating a wafer

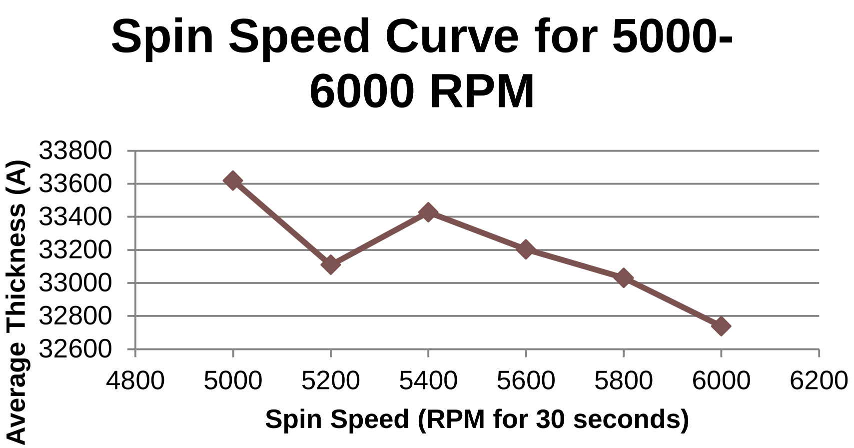


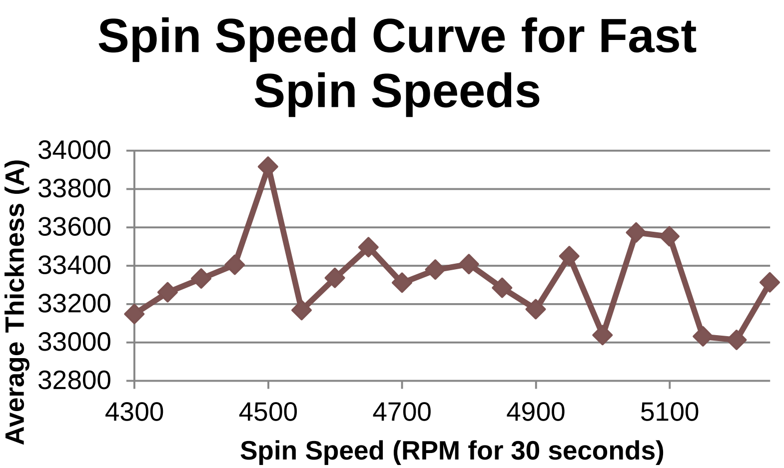
The photoresist spins radially outward because of the centripetal force. The center is the thickest and the edges are the thinnest.

Spin Speed Curves







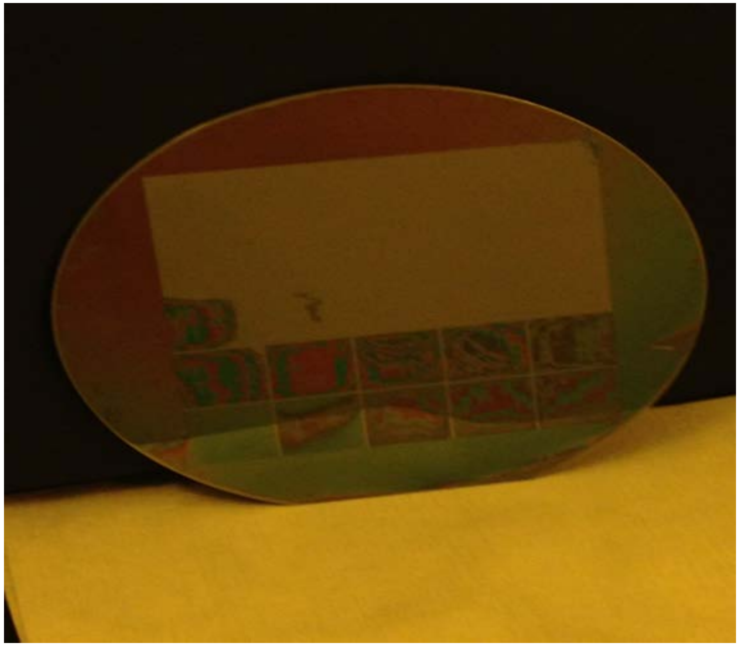


Trial 1

Trial 2

E0 Clear Energy

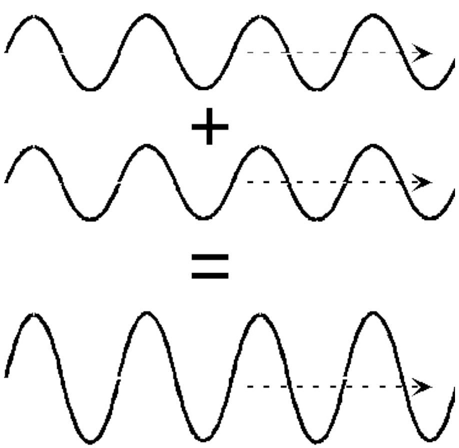
- Use the ASML300 stepper to expose wafers to UV light
- Use svgdev6 to develop wafers



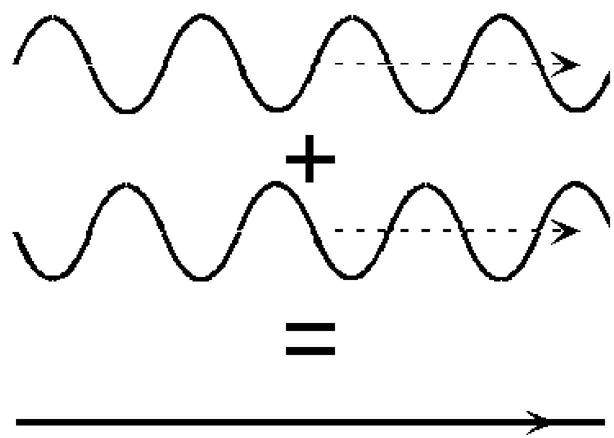
- Trial 1: PEB at 130 C
- Trial 2: PEB at 110 C
- Find at which energy the photoresist clears. Record and graph a swing/interference curve.

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



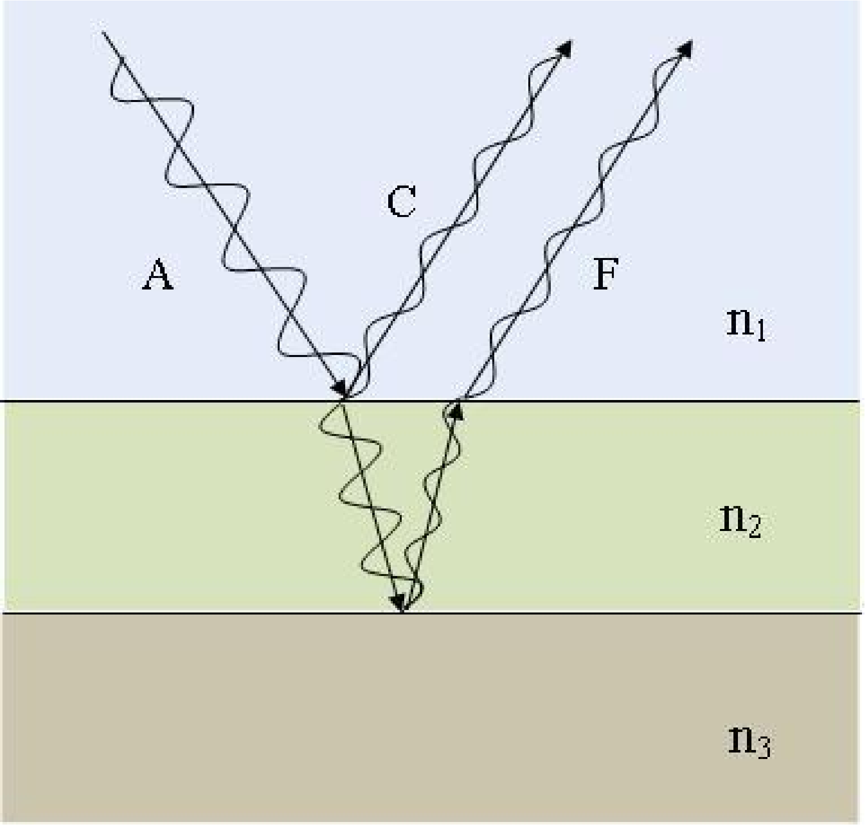
constructive

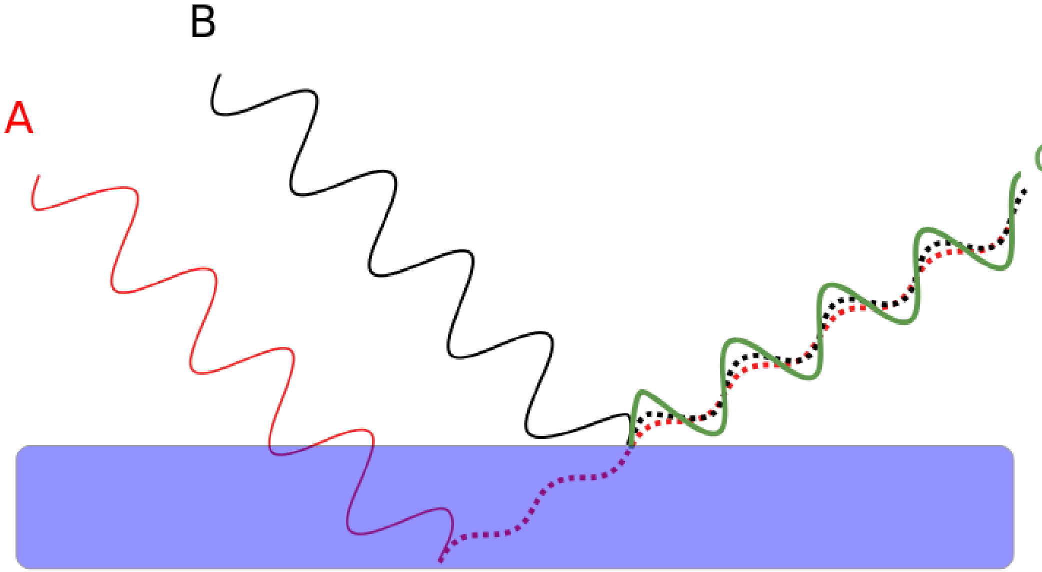


destructive

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

Interference/Swing Curves



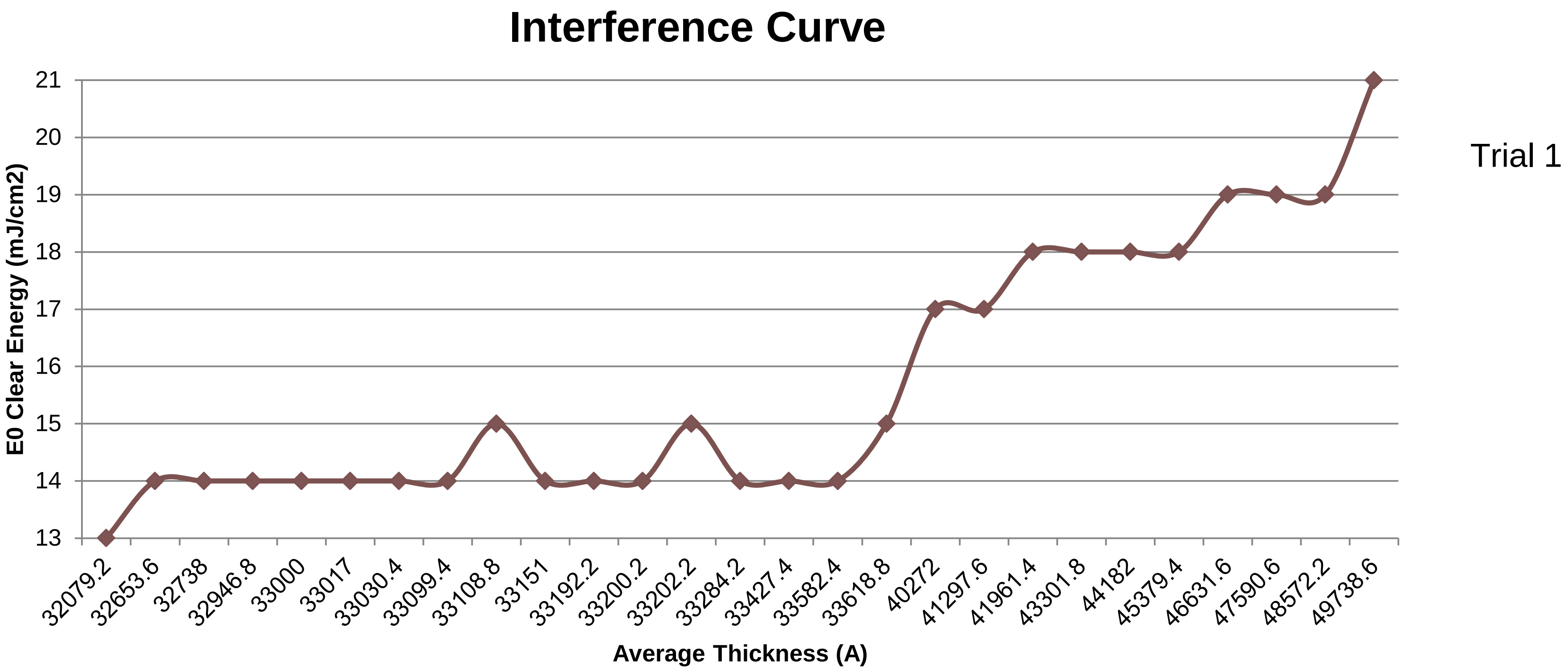


Destructive

Constructive

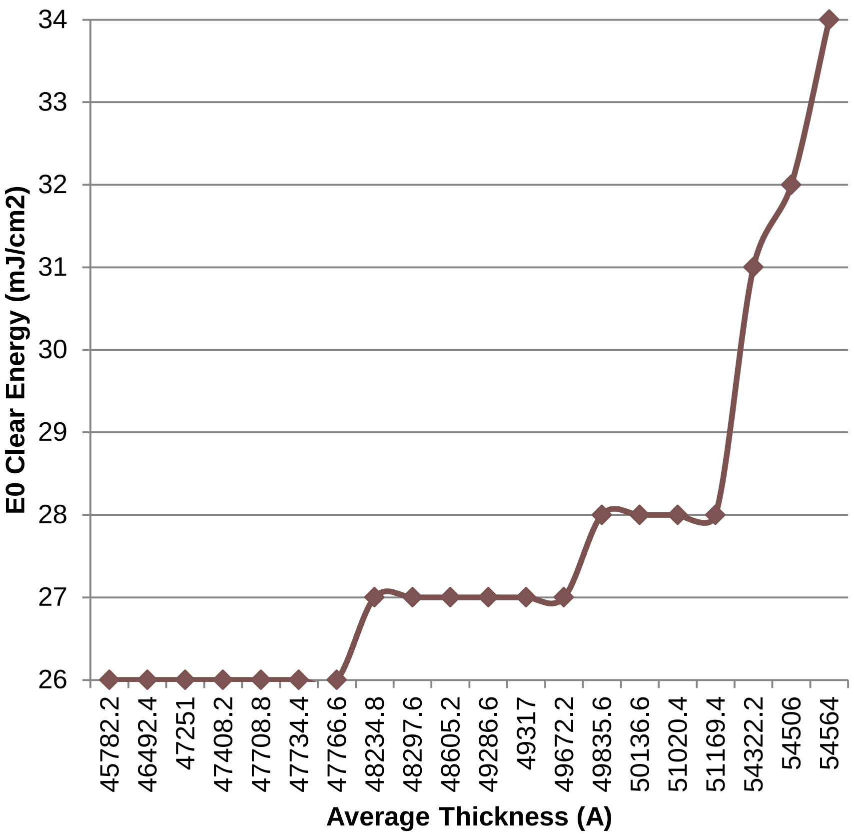
Interference/Swing Curves

- Ideal graph has a sinusoidal pattern
- Actual graphs:

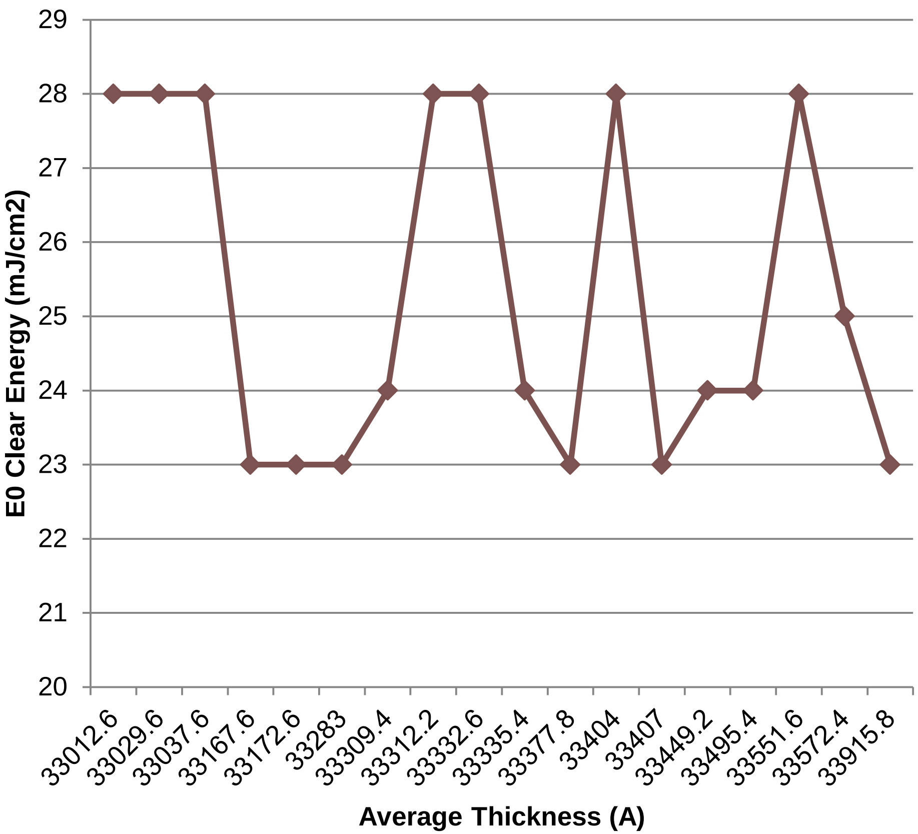


Trial 2

Interference Curve for Slow Spin Speeds (Thicker Coat)

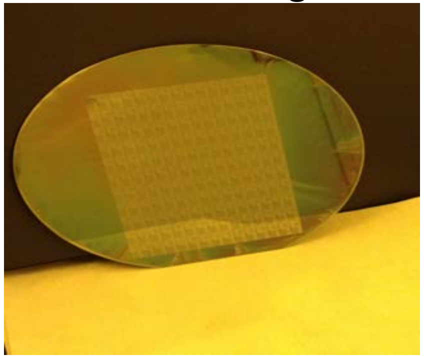


Interference Curve for Fast Spin Speeds (Thinner Coat)



Focus/Exposure Matrix CMOS200

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

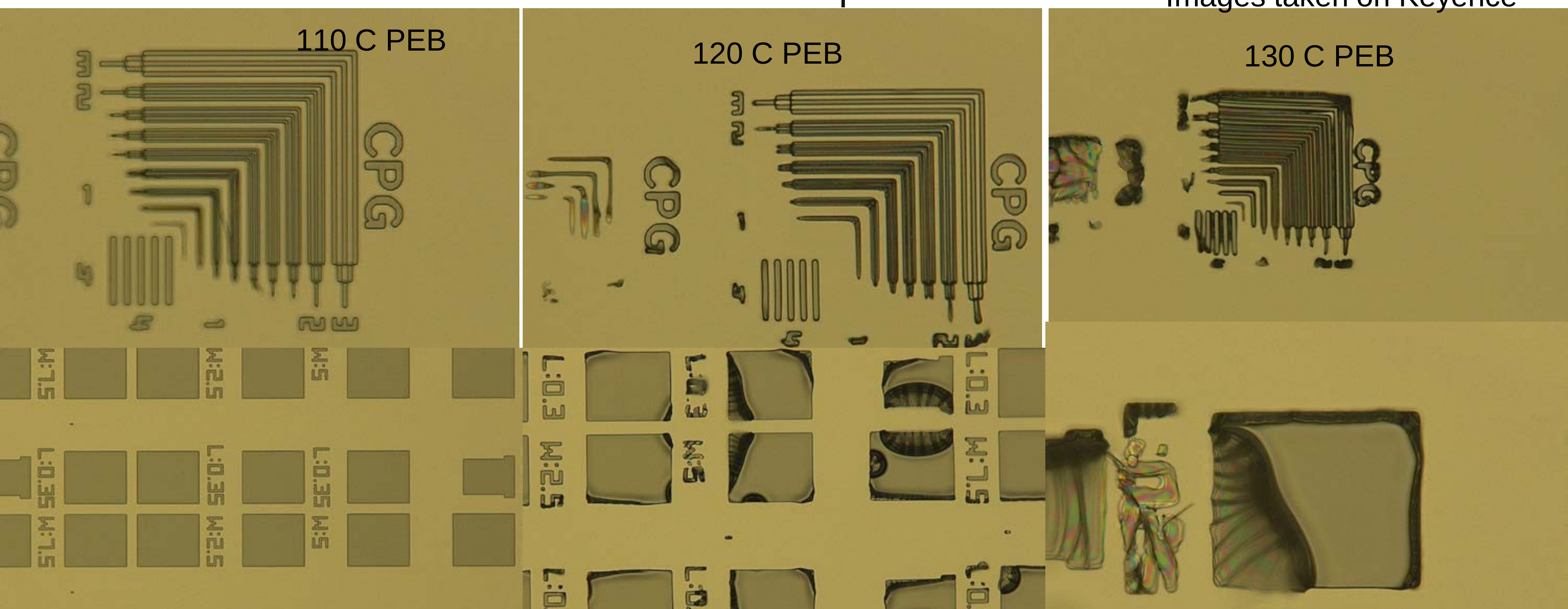


- Purpose of FEM: use uvscope to find the right exposure and focus to have a clear, fully developed image
- Difficulties?
  - Finding the most clear image of 165 options per wafer (we examined 20 wafers)
  - Underexposed, overexposed, or damaged?

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.

Images taken on Keyence



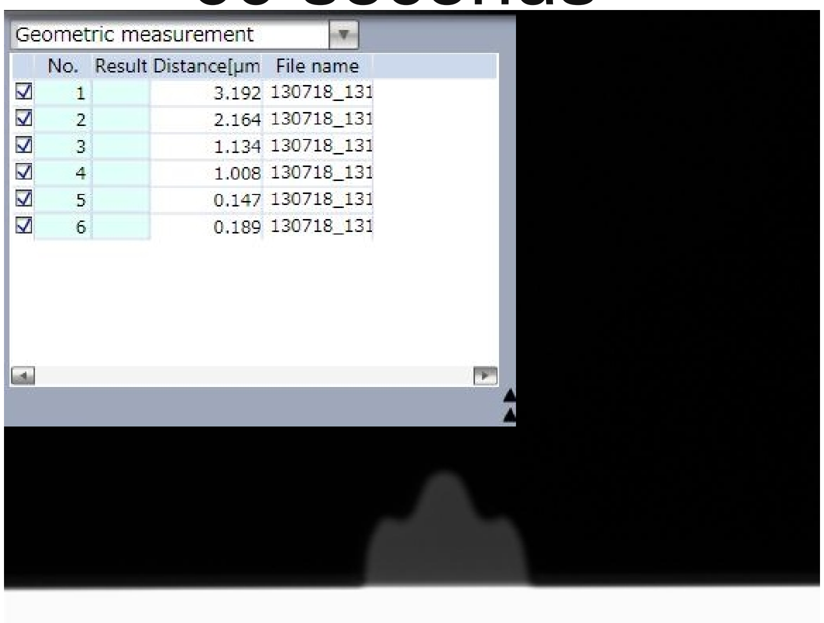
Soft Bake (SB)

- 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

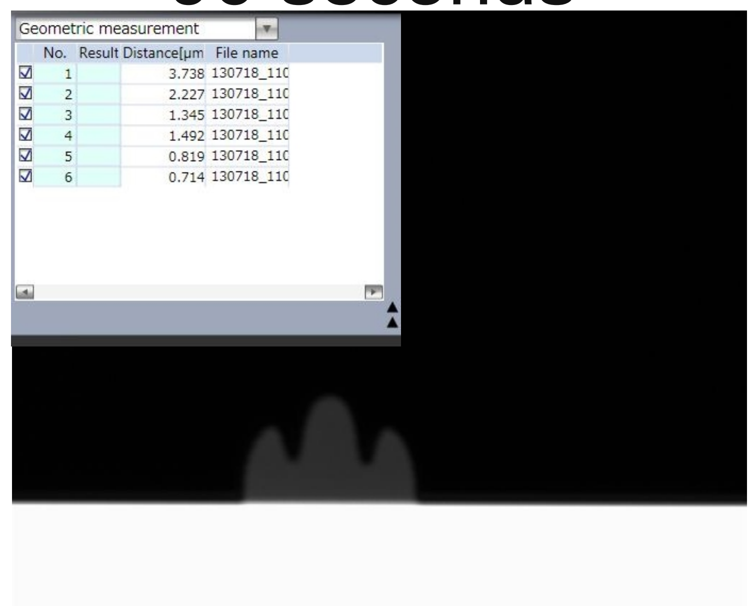


Geometric measurement

No.	Result	Distance[μm	File name
1		3.192	130718_131
2		2.164	130718_131
3		1.134	130718_131
4		1.008	130718_131
5		0.147	130718_131
6		0.189	130718_131

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

90 seconds



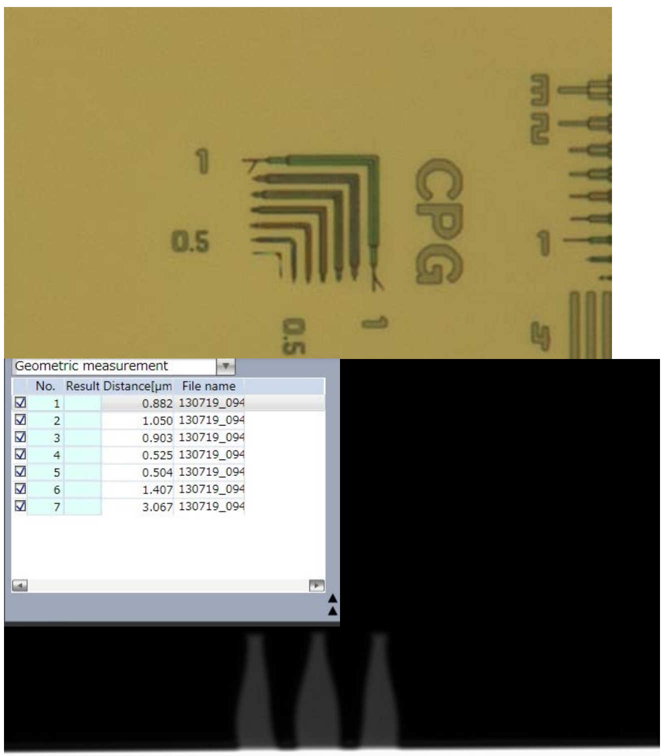
Geometric measurement

No.	Result	Distance[μm	File name
1		3.738	130718_110
2		2.227	130718_110
3		1.345	130718_110
4		1.492	130718_110
5		0.819	130718_110
6		0.714	130718_110

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

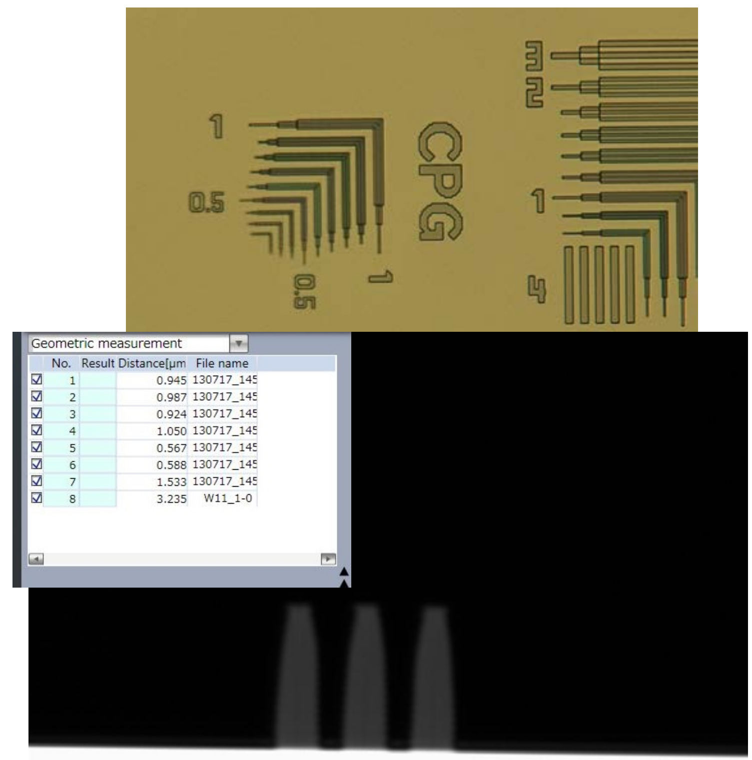
Comparing Soft Bake 130 C with 140 C at 5000 RPM, PEB at 110 C for 60 sec

130 C



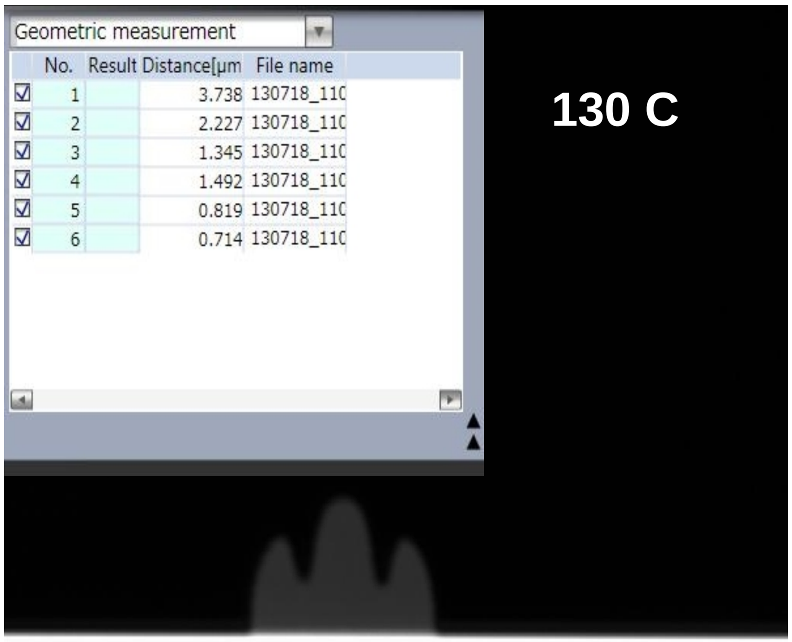
Wafer 8A: 1.0 um forks, 32000A,
SB 130 for 90 sec, PEB 110 for 60 sec,
29 mJ/cm2, focus: 2.0

140 C

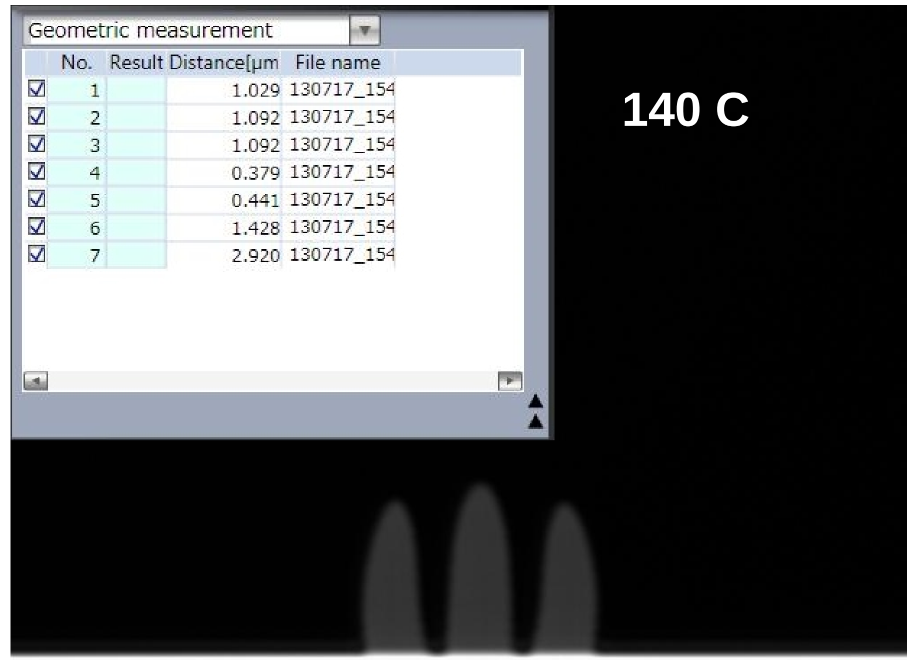


Wafer 11: 1.0um forks, 31854A,
SB 140 C for 90 sec,
PEB 110 C for 60 sec,
27mJ/cm2, focus: 1.6

Comparing Soft Bakes 130 C with 140 C at 1000 RPM, PEB at 110 C for 60 sec

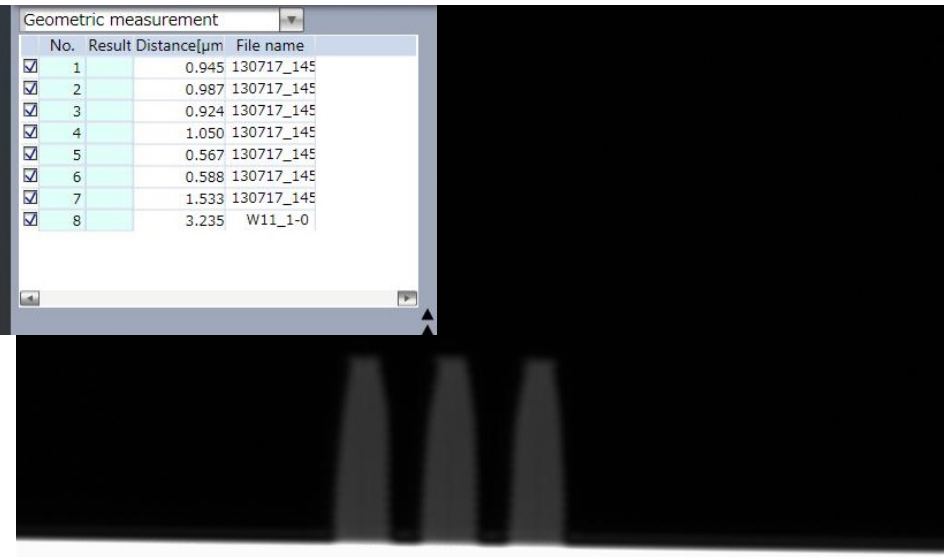


Wafer 7A: 1.0um forks, 49867A,
SB 130 for 90 sec, PEB 110 for 60 sec,
51 mJ/cm2, focus: 3.2



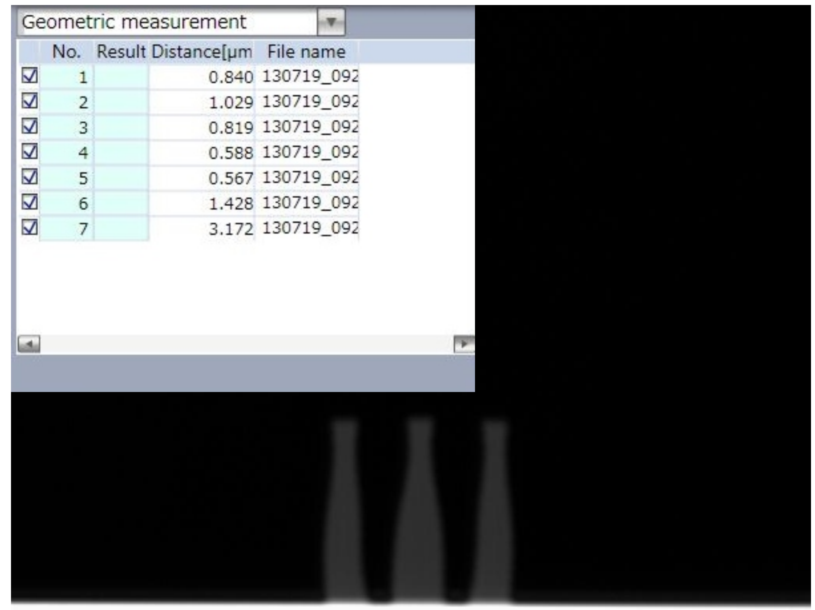
Wafer 10: 1.0 um forks, 49018A,
SB 140 C for 90 sec, PEB 110 for 60 sec,
43 mJ/cm2, focus: 2.4

Comparing 140 C with 130 C at longer times, 5000 RPM ~= 3.2um



No.	Result	Distance[µm	File name
1		0.945	130717_145
2		0.987	130717_145
3		0.924	130717_145
4		1.050	130717_145
5		0.567	130717_145
6		0.588	130717_145
7		1.533	130717_145
8		3.235	W11_1-0

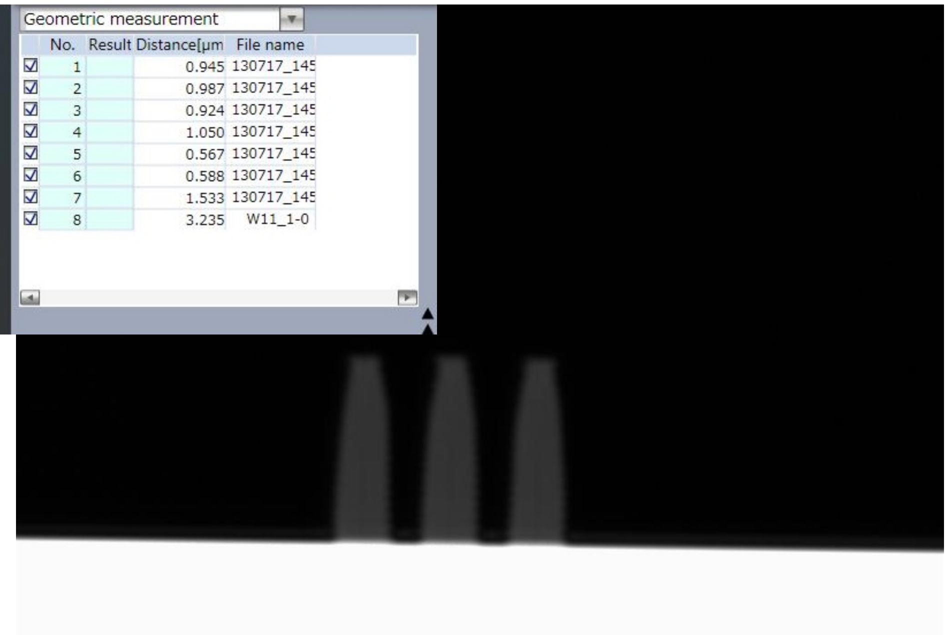
Wafer 11: 1.0um forks, 31854A,
SB 140 C for 90 sec,
PEB 110 C for 60 sec, 27mJ/cm2,
focus: 1.6



No.	Result	Distance[µm	File name
1		0.840	130719_092
2		1.029	130719_092
3		0.819	130719_092
4		0.588	130719_092
5		0.567	130719_092
6		1.428	130719_092
7		3.172	130719_092

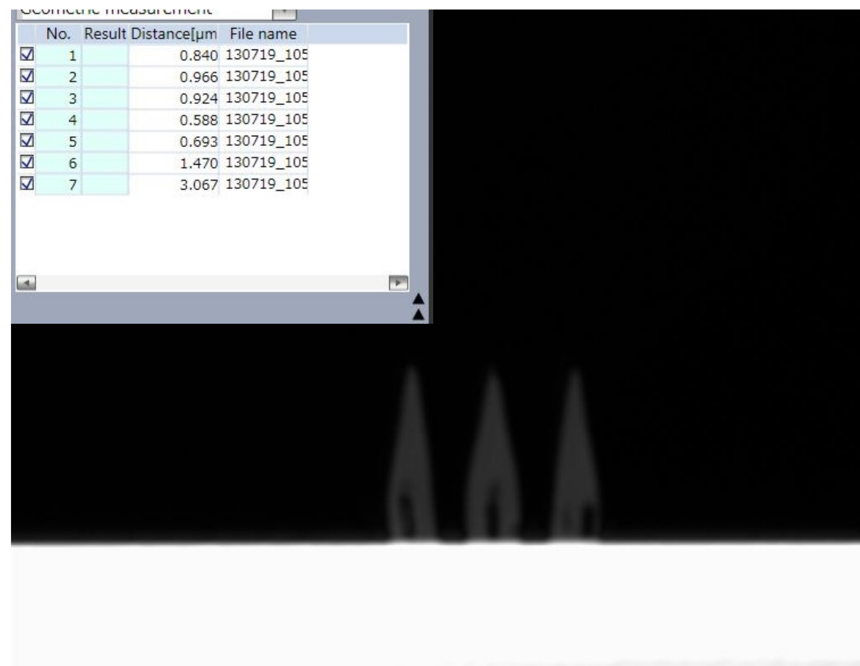
Wafer 12: 1.0 um forks, ~32000A,
SB 130 C for 120 sec, PEB 110 C for 60 sec,
33 mJ/cm2, focus: 1.2

[redacted]



No.	Result	Distance[μm	File name
1		0.945	130717_145
2		0.987	130717_145
3		0.924	130717_145
4		1.050	130717_145
5		0.567	130717_145
6		0.588	130717_145
7		1.533	130717_145
8		3.235	W11_1-0

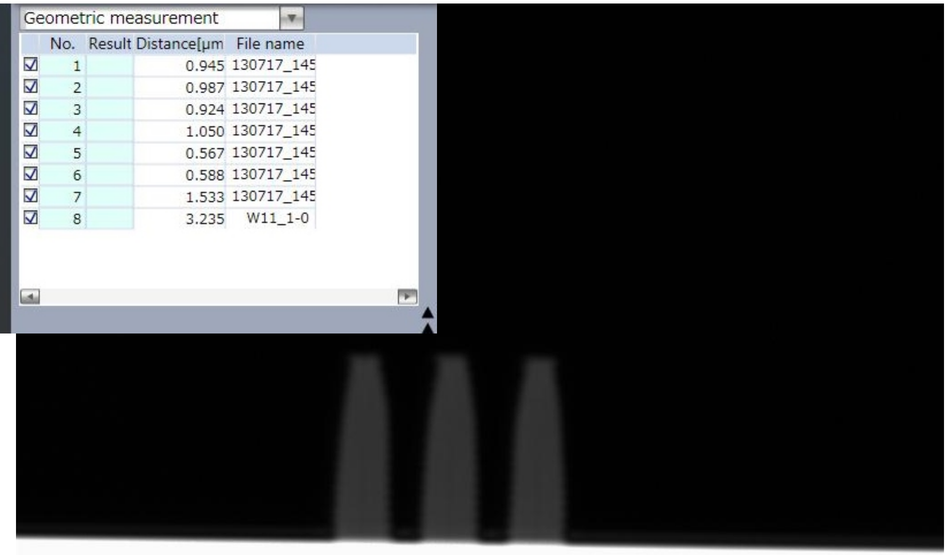
Wafer 11: 1.0um forks, 31854A,
SB 140 C for 90 sec,
PEB 110 C for 60 sec, 27mJ/cm2,
focus: 1.6



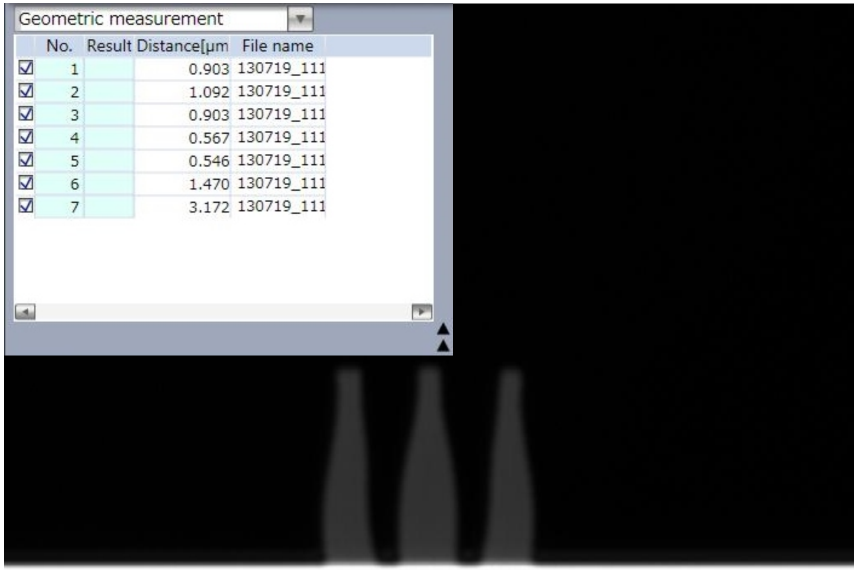
No.	Result	Distance[μm	File name
1		0.840	130719_105
2		0.966	130719_105
3		0.924	130719_105
4		0.588	130719_105
5		0.693	130719_105
6		1.470	130719_105
7		3.067	130719_105

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

[redacted]

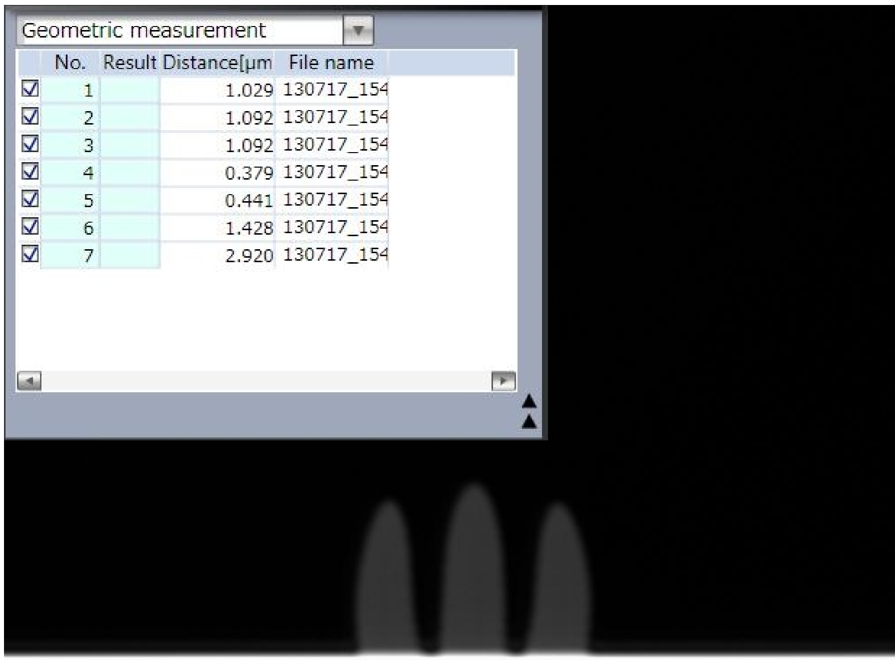


Wafer 11: 1.0um forks, 31854A,
SB 140 C for 90 sec,
PEB 110 C for 60 sec, 27mJ/cm2,
focus: 1.6

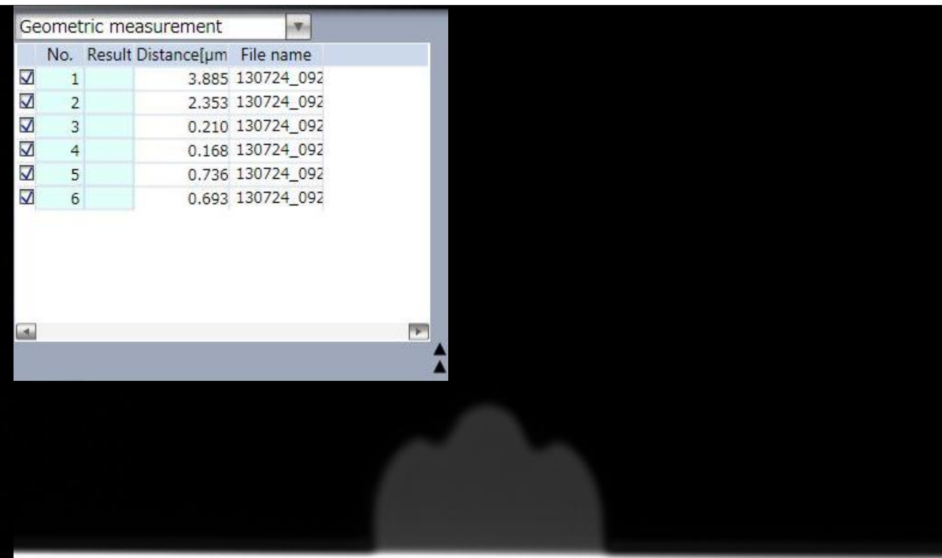


Wafer 14: 1.0 um forks, ~32000 um,
SB 130 for 300 sec, PEB 110 for 60 sec, 29 mJ/cm2,
focus: 1.6

Comparing 140 C with 130 C at Longer Times, 1000 RPM ~=4.7 um

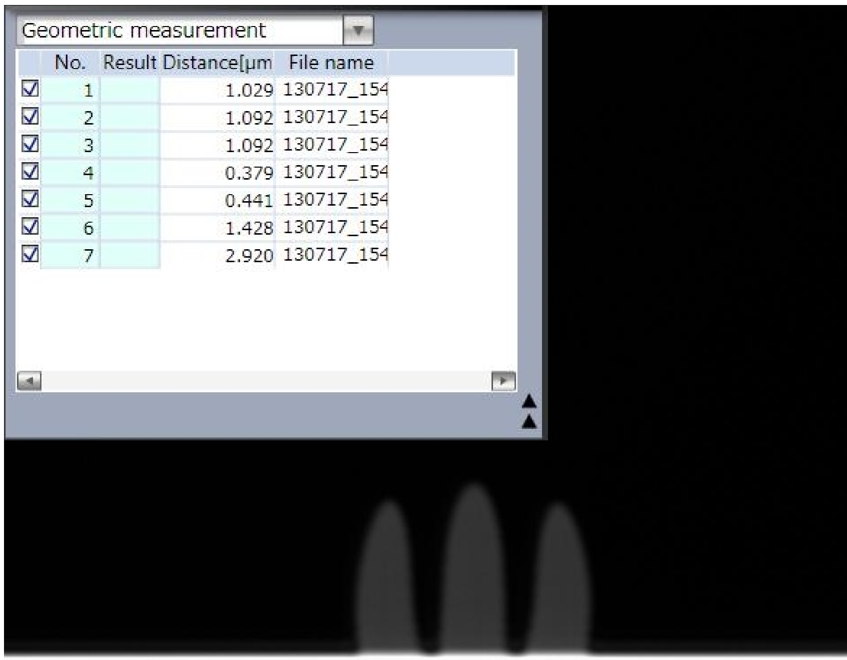


Wafer 10: 1.0 um forks, 49018A,
SB 140 C for 90 sec, PEB 110 for 60 sec,
43 mJ/cm2, focus: 2.4



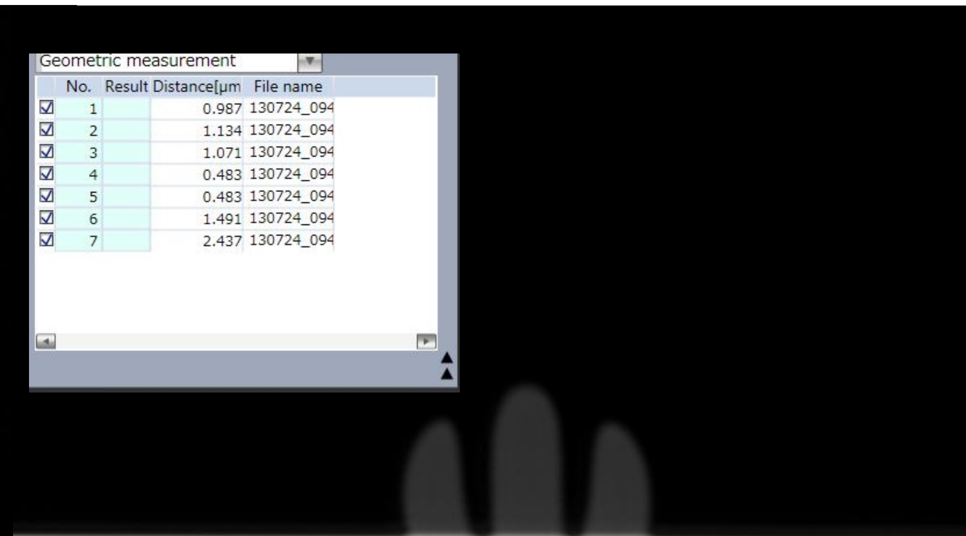
Wafer 15: 1.0 um forks, ~47000A,
SB 130 C for 120 sec, PEB 110 C for 60 sec,
41 mJ/cm2, focus: 2.8

[redacted]



No.	Result	Distance[µm	File name
1		1.029	130717_154
2		1.092	130717_154
3		1.092	130717_154
4		0.379	130717_154
5		0.441	130717_154
6		1.428	130717_154
7		2.920	130717_154

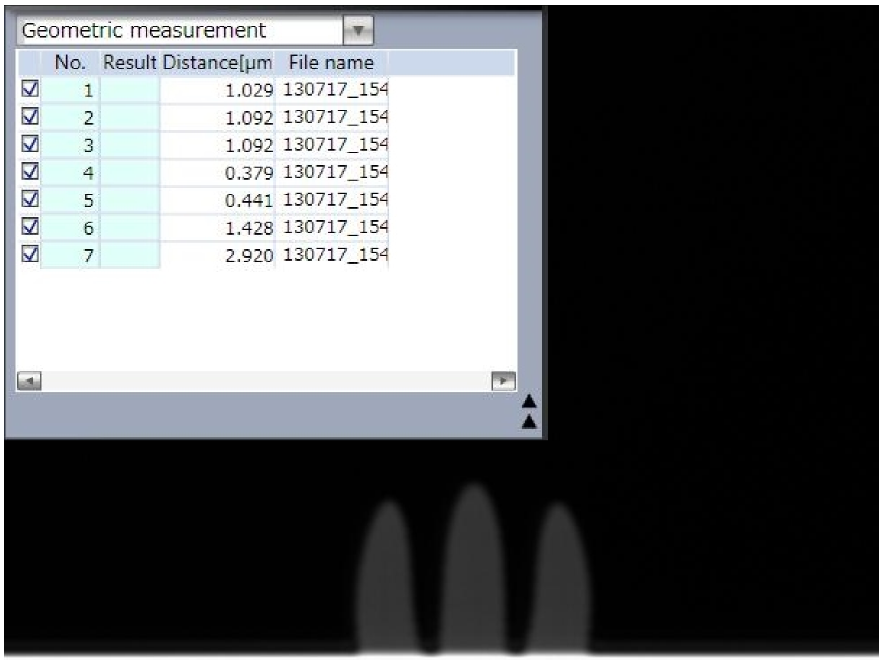
Wafer 10: 1.0 um forks, 49018A,
SB 140 C for 90 sec, PEB 110 for 60 sec,
43 mJ/cm2, focus: 2.4



No.	Result	Distance[µm	File name
1		0.987	130724_094
2		1.134	130724_094
3		1.071	130724_094
4		0.483	130724_094
5		0.483	130724_094
6		1.491	130724_094
7		2.437	130724_094

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

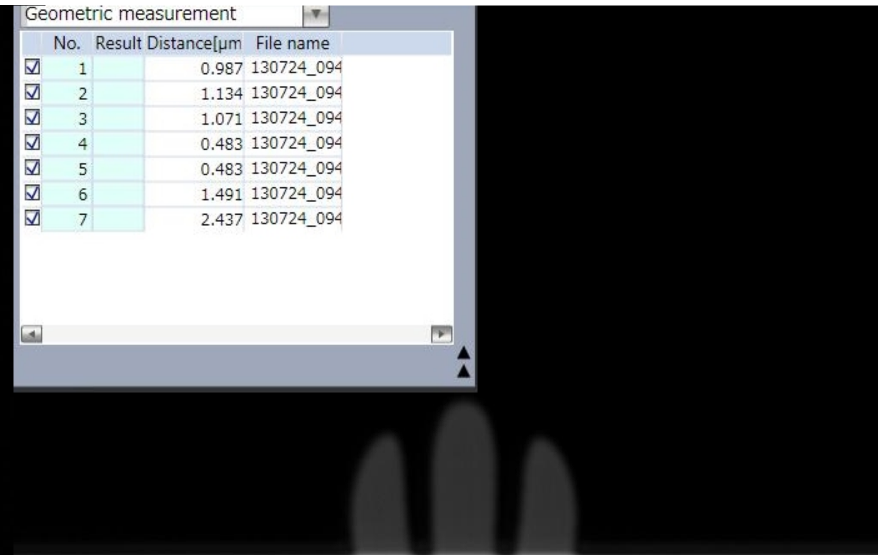
[redacted]



Geometric measurement

No.	Result	Distance[µm	File name
1		1.029	130717_154
2		1.092	130717_154
3		1.092	130717_154
4		0.379	130717_154
5		0.441	130717_154
6		1.428	130717_154
7		2.920	130717_154

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



Geometric measurement

No.	Result	Distance[µm	File name
1		0.987	130724_094
2		1.134	130724_094
3		1.071	130724_094
4		0.483	130724_094
5		0.483	130724_094
6		1.491	130724_094
7		2.437	130724_094

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:

Wafer # SB temp SB time	Without any wafer	1 140 C 60 sec	2 140 C 60 sec	3 140 C 90 sec	4 140 C 120 sec	5 130 C 60 sec	6 130 C 90 sec	7 130 C 120 sec
Leak Rate	.06 mTorr/min	.06 mTorr/min	.08 mTorr/min	.06 mTorr/min	.06 mTorr/min	.08 mTorr/min	.06 mTorr/min	.08 mTorr/min

Conclusions

Best Conditions

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

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.