Characterizing LiftOff Process Latitude at the UC Berkeley Nanolab

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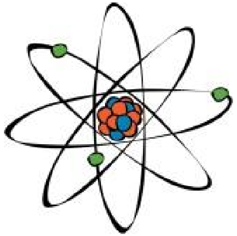
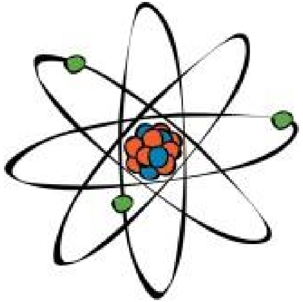




"What would our librarian at Caltech say, as she runs all over from one building to another, if I tell her that, ten years from now, all of the information that she is struggling to keep track of [....] can be kept on just one library card!"

-Richard Feynman

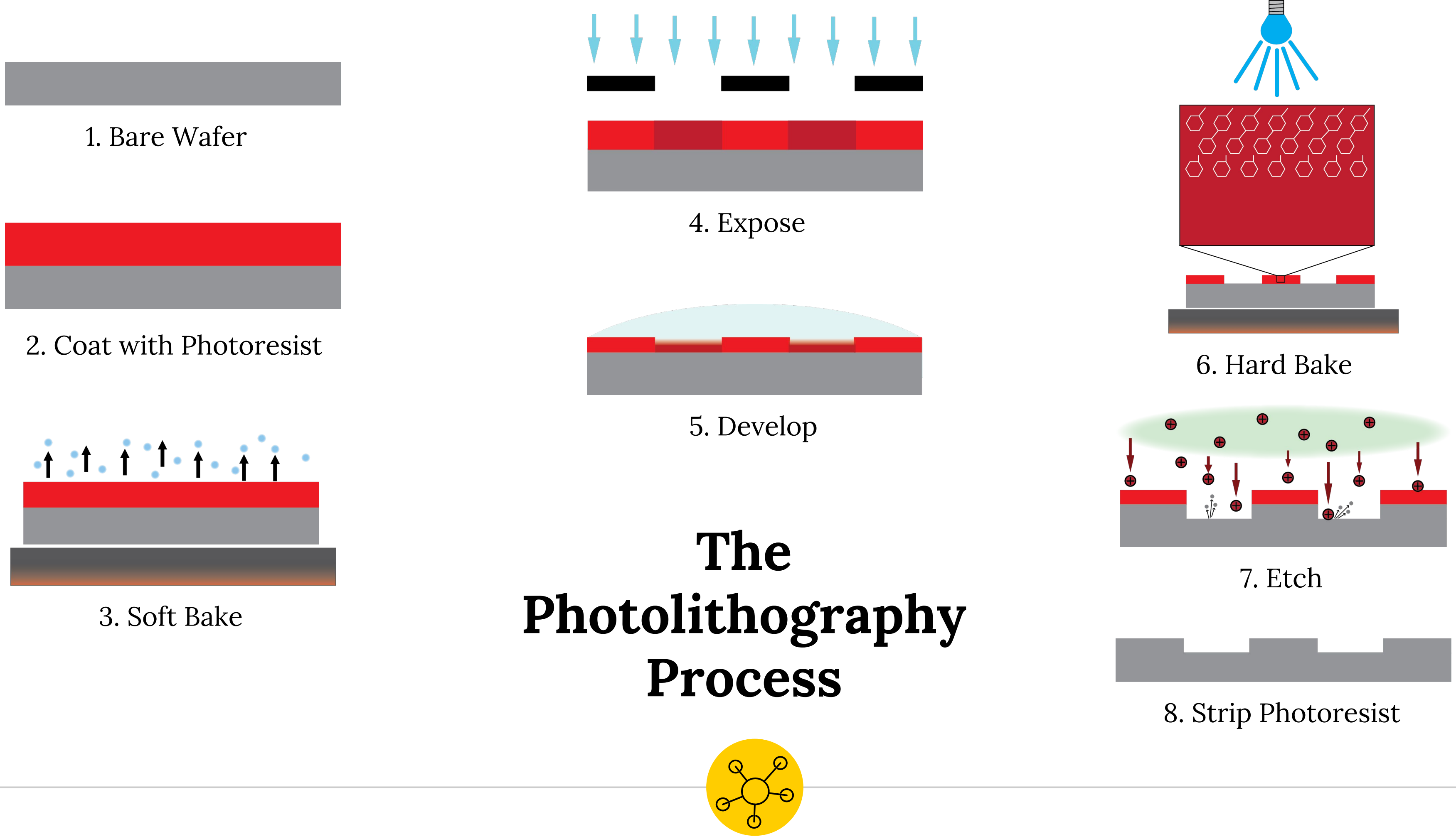
"

"There's Plenty of Room at the Bottom," Richard Feynman, 1959.

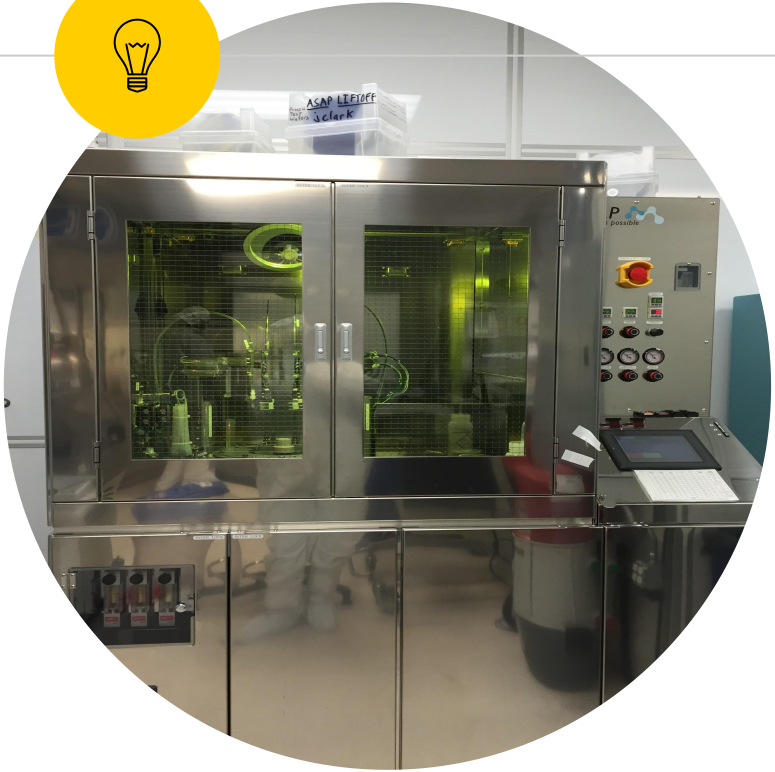
Introduction to Photolithography

How we pattern films on a microchip.

The Photolithography Process



Original images created by Alam Figueroa



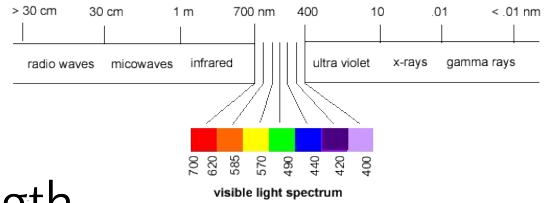
What is ASAP liftoff?

The ASAP Liftoff tool is used to:

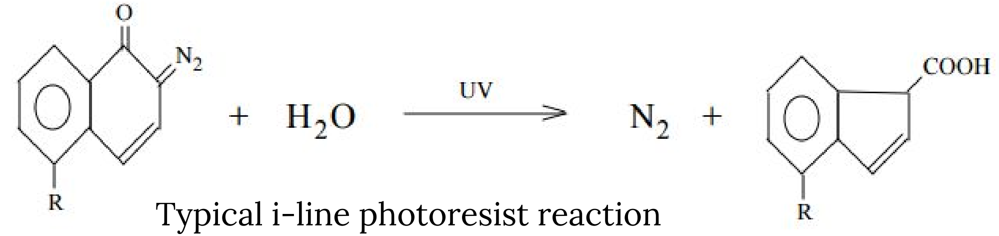
1) Strip photoresist

2) Pattern metal via liftoff

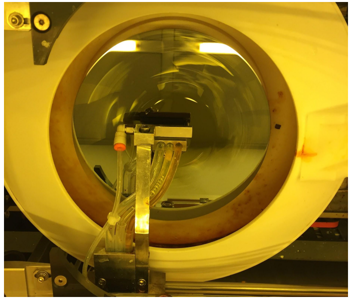
What is photoresist?



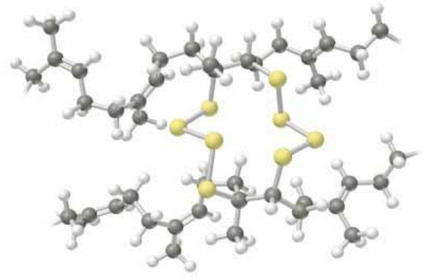
- Photo-sensitive coating material
- Sensitive to UV light at a certain wavelength
- Exposure to light results in the production of acid which can later be removed by an alkaline developer
- Ex. g-line, i-line, DUV (chemically amplified)



Typical i-line photoresist reaction



Why is the photoresist heated?



(b)

Intended Heating

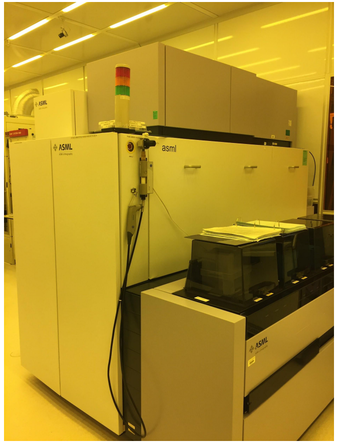
– Drives out solvents and densifies the resist

– Produces acid in exposed areas (DUV chemical amplification)

Unintended Heating

Etching and other heat intensive processes cause the polymer chains to crosslink and further modifies the resist. This can result in challenges when stripping the resist from the wafer.

http://wps.prenhall.com/wps/media/objects/3312/3391650/blb1202.html



asml

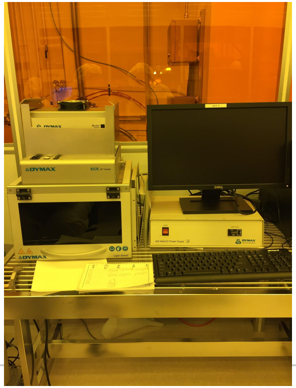
svgcoat6

svgdev6

primeoven

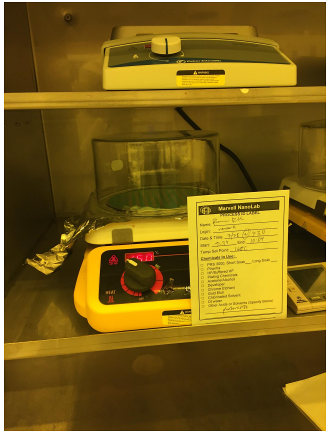
svgcoat3

Tools Used for Experimentation



uvflood

Even More Tools

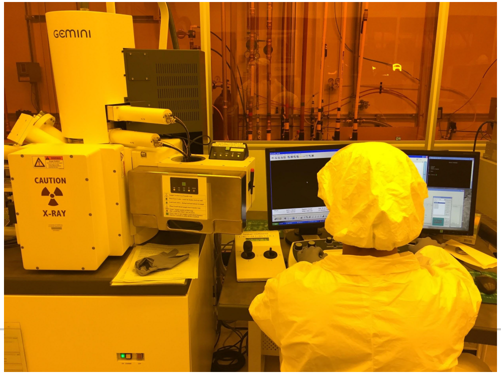


hotplates

asiq

ASAP Liftoff

cha



zeiss-sem

Experiment One

How does heat impact our ability to strip photoresist?

Experimental Procedure

Coat

Expose/Develop

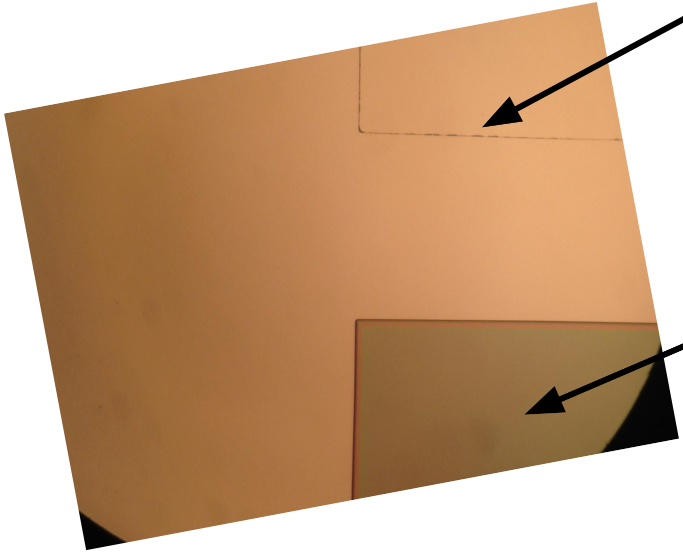
Thermal Treatment

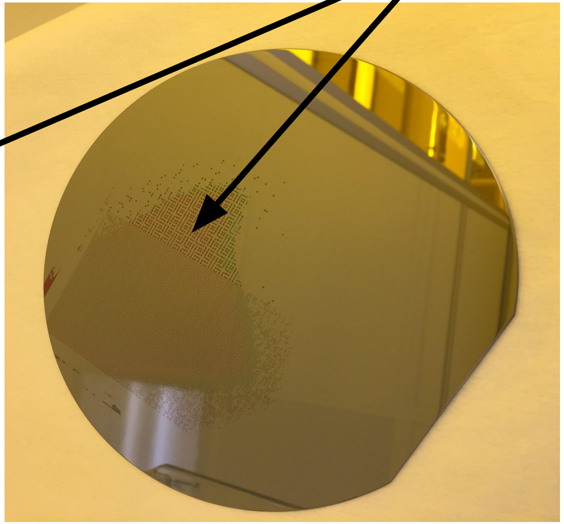
Strip

Temperature ranging from 120 to 260℃

Fence defect

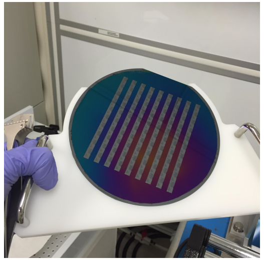
Incomplete photoresist removal



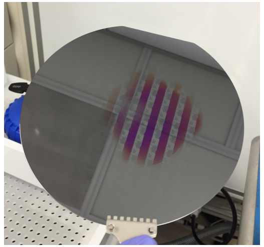


OiR 906-12 i-line resist exposed to temperatures from 120℃-260℃ were not successfully stripped.

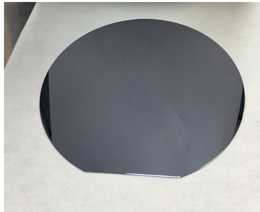
Strip recipe:
60 sec, 20 MPa, NMP



260℃



220℃



160℃

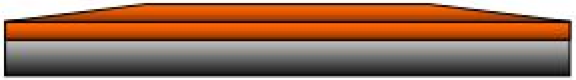
DUV 210 photoresist was readily removed if kept to temperatures under 160℃

Run	Temperature	Strip	Comment
1	120℃	yes	Readily strips
2	140℃	yes	Readily strips
3	160℃	yes	Readily strips
4	180℃	partial	Photoresist fencing defects
5	200℃	partial	~ 15% photoresist remaining
6	220℃	no	~ 30% photoresist remaining
7	240℃	no	Photoresist film remaining
8	260℃	no	Photoresist film remaining

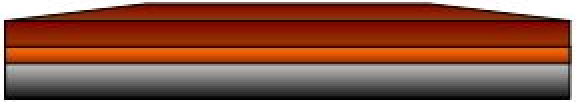
Experiment Two

How does LOR soft-bake temperature affect the liftoff process?

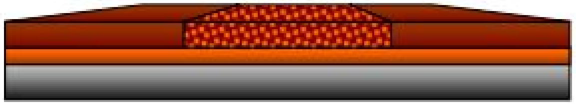
The Liftoff Process



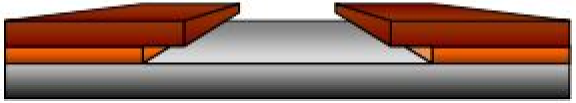
1. Coat and Soft-bake PMGI or LOR.



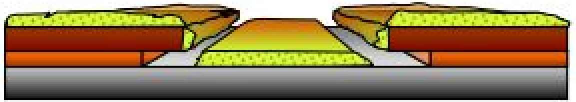
2. Coat and Soft-bake Imaging Resist.



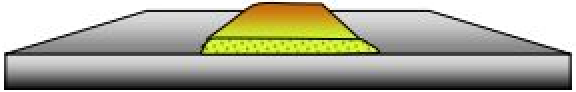
3. Expose Imaging Resist.



4. Develop resist and PMGI/LOR.

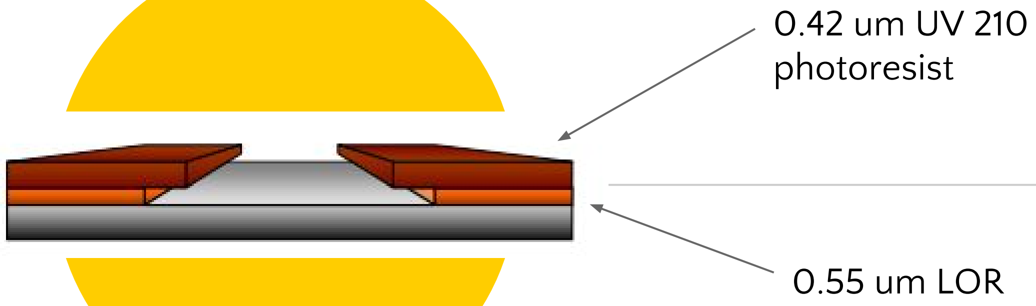


5. Deposit film.



6. Lift-off Bi-layer stack and residual deposition.

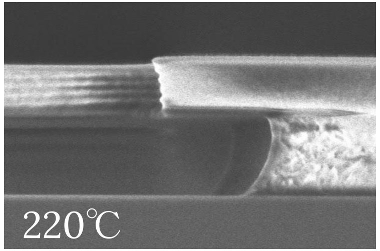
Microchem-PMGI Resist Data Sheet

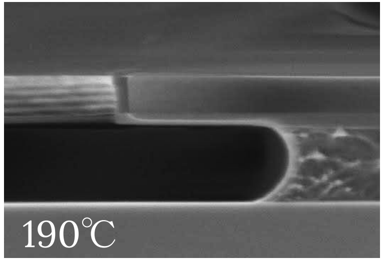


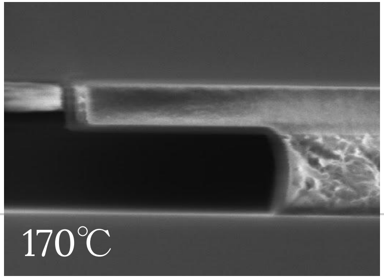
T-top Bilayer

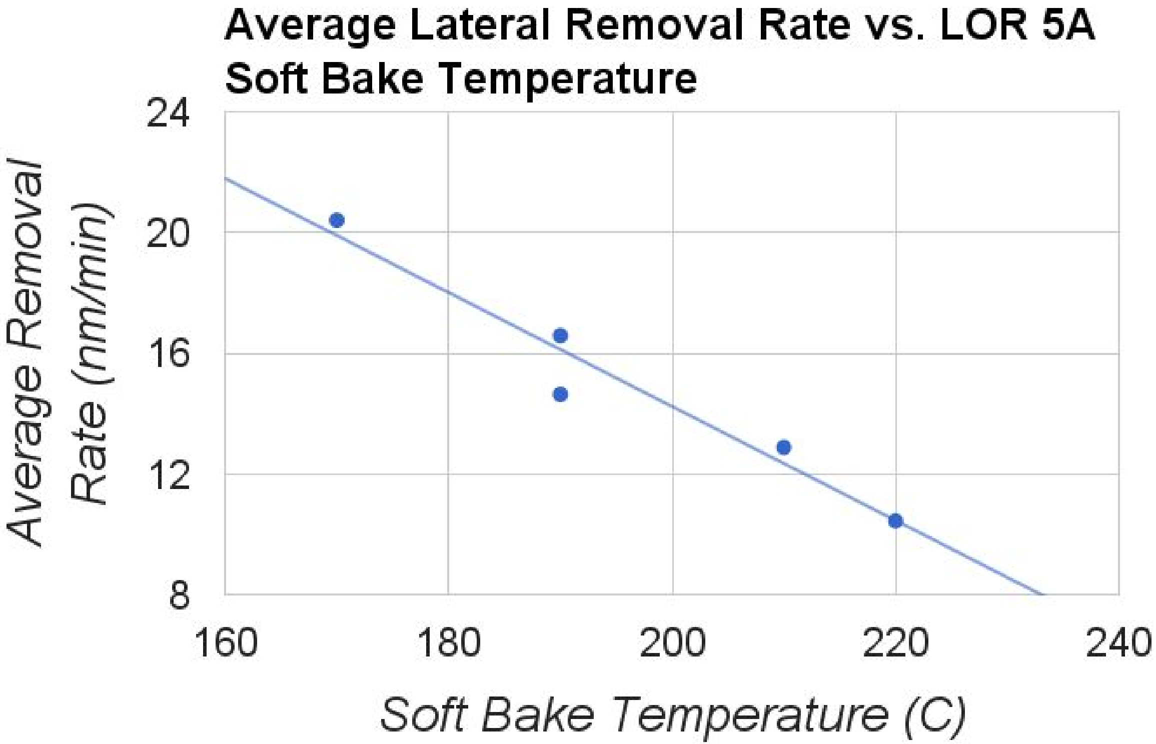
The final bilayer thickness is 0.97 um

Svgdev6: MF26 for 60 sec









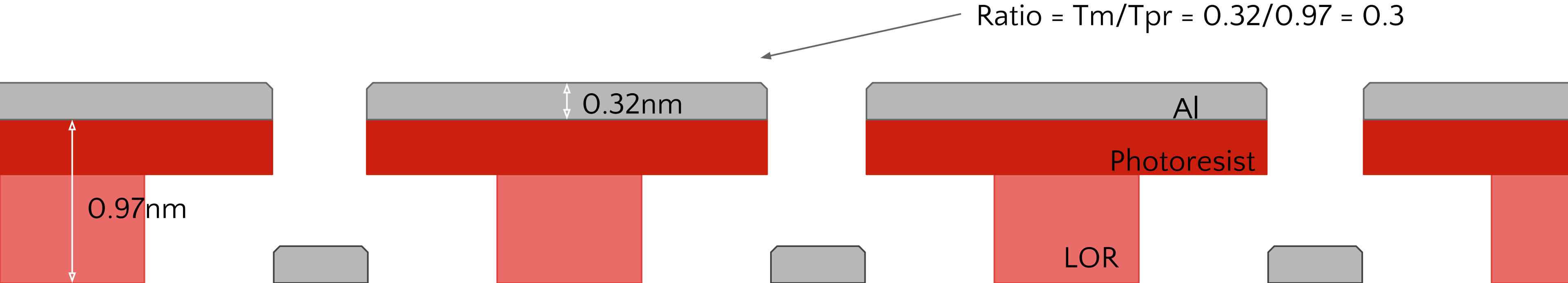
y= −0.189x + 52.01 r^2=0.948

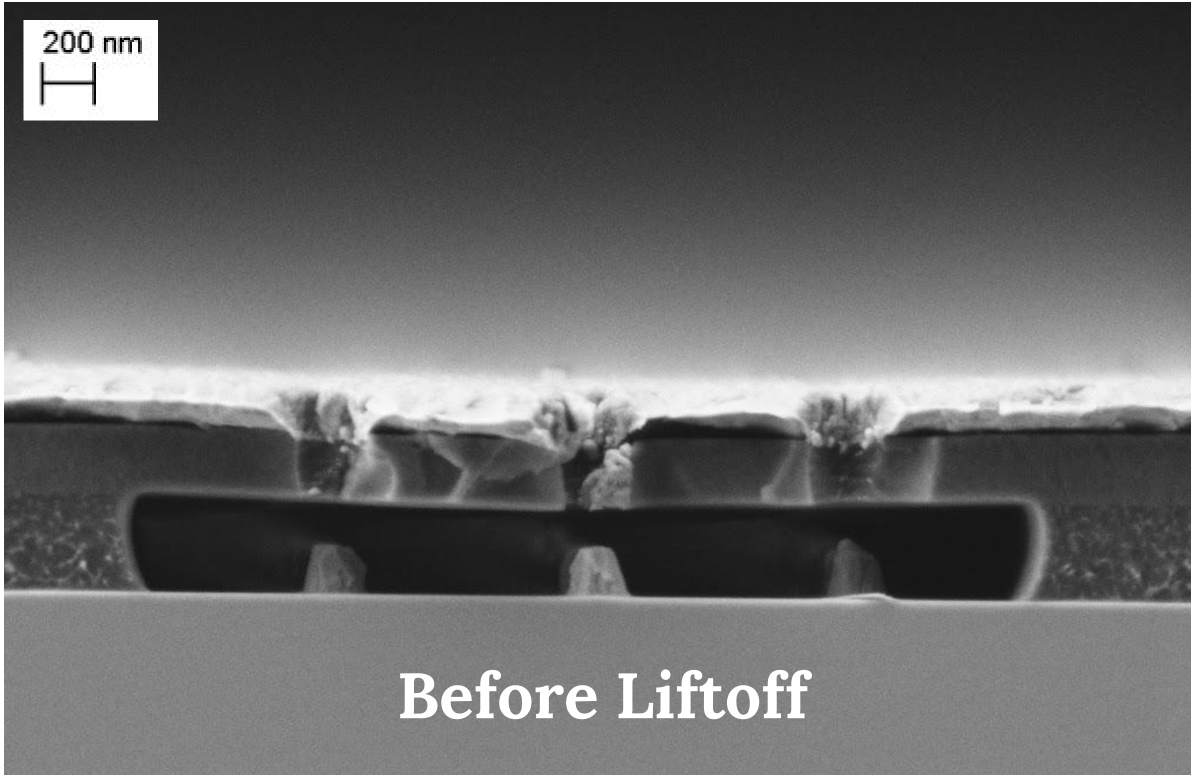
Experiment Three

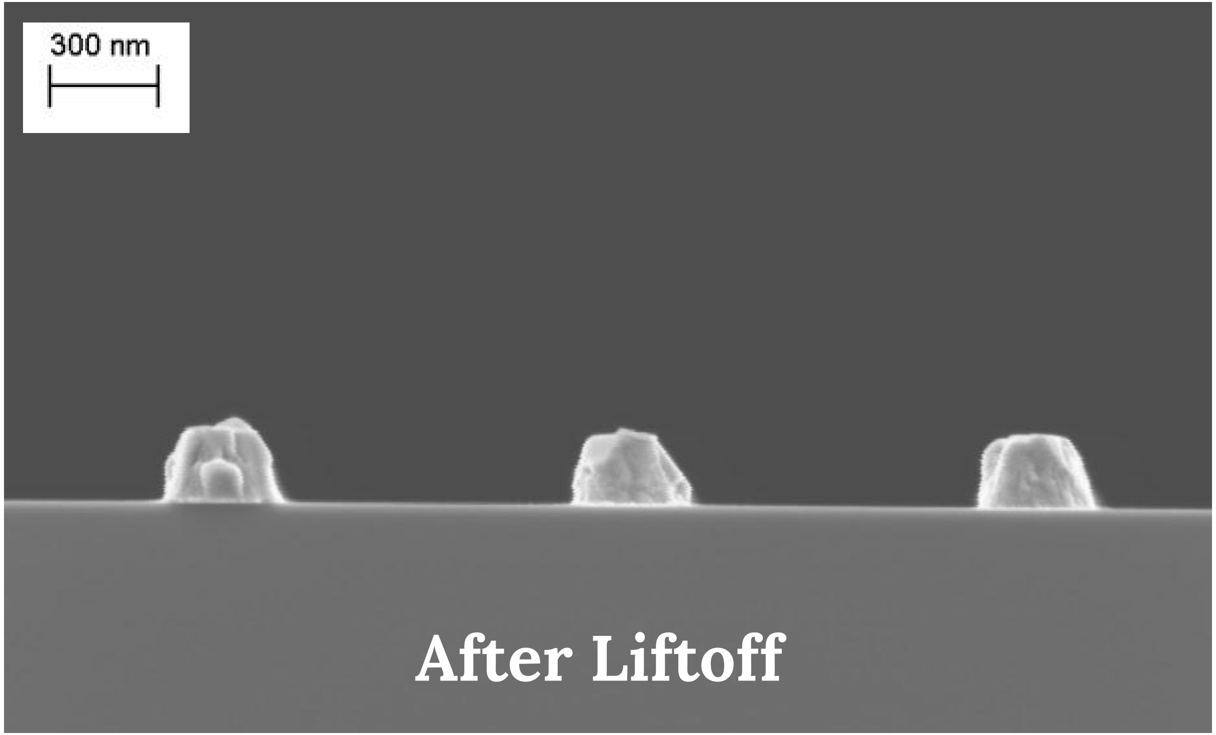
How does the ratio of deposited metal to bilayer resist thickness affect the liftoff process?

Metal to Photoresist Ratio

- A ratio of 0.30 is industry standard
- Our experiments ranged from 0.30 to 1.05
- Assess inability to lift off resist or loss of fidelity in metal pattern



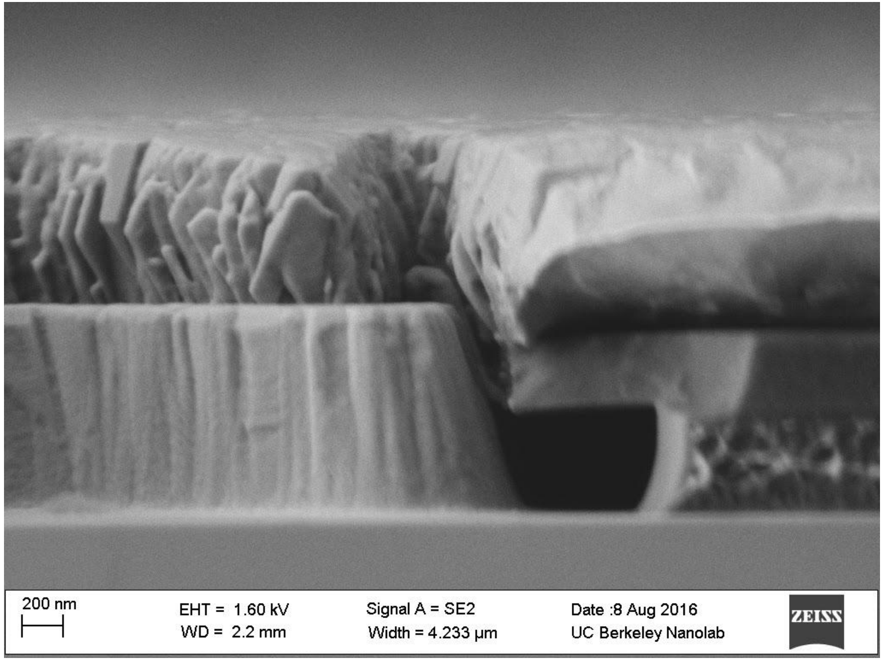

200 nm
Before Liftoff

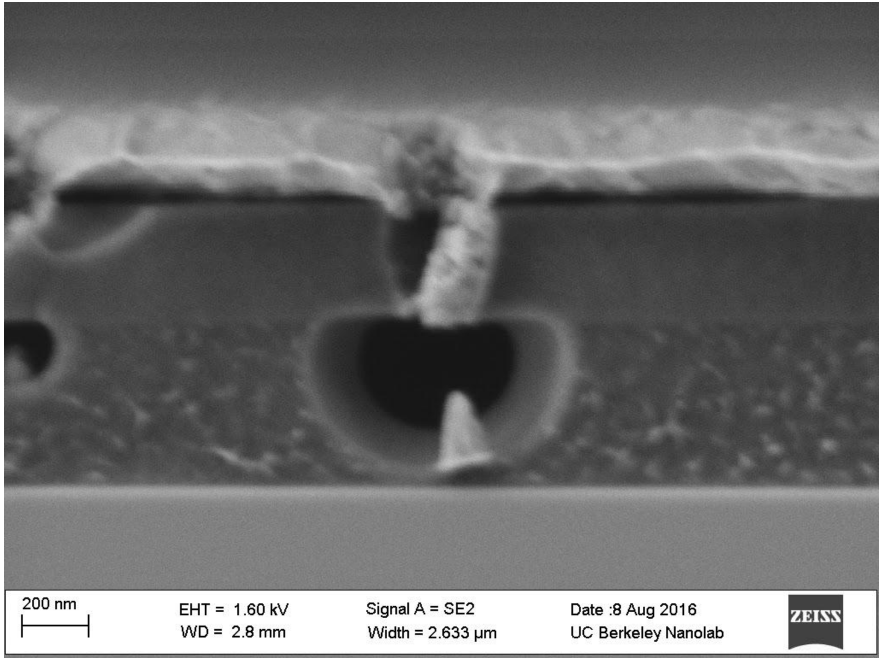

300 nm
After Liftoff

Metal to Bilayer Thickness Ratio and Feature Size Achieved

Approximate metal to bilayer thickness ratio	**0.25 um feature**	**0.35 um feature**	**0.5 um feature**
0.30	yes	yes	yes
0.50	no	yes	yes
0.65	no	yes	yes
0.75	no	yes	yes
0.85	no	yes (rough)	yes
0.95	no	yes (rough)	yes
1.05	no	no	no

Failure Modes





Conclusions

- It is difficult to strip i-line resist. DUV 210 resist readily strips if the exposed temperature stays below 160℃
- There is an inverse relationship between LOR 5A soft bake temperature and its lateral removal rate. The removal rate decreases by an average of 0.19 nm/min/℃.
- A deposited metal to bilayer thickness ratio or less than 0.95 was shown to exhibit successful litoff resulting in features of 0.35 um. For best fidelity, it is recommended to use a ratio or 0.75 or lower.

Acknowledgements

Special thanks to:

- Bill Flounders
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- Marvell Nanolab Staff, especially Kim Chan, Ryan Rivers, Greg Mullins, David Lo, and Glenn Kewley
- Nanolab Student Staff, especially Hongling Liu, Richard Soto, Annie Xie, and Alam Figueroa

Thanks!

Any questions ?