



NanoLab 2024 Principal Investigators Meeting

*"The great thing about the
Microlab is the way it evolves."*

UC Berkeley EECS Professor,
William G. Oldham



Professor Kris Pister

Dr. Bill Flounders

Dr. Michael Helmbrecht

Faculty Director

Executive Director (Ret.)

Executive Director (Eff. Feb 1, 2025)



Agenda

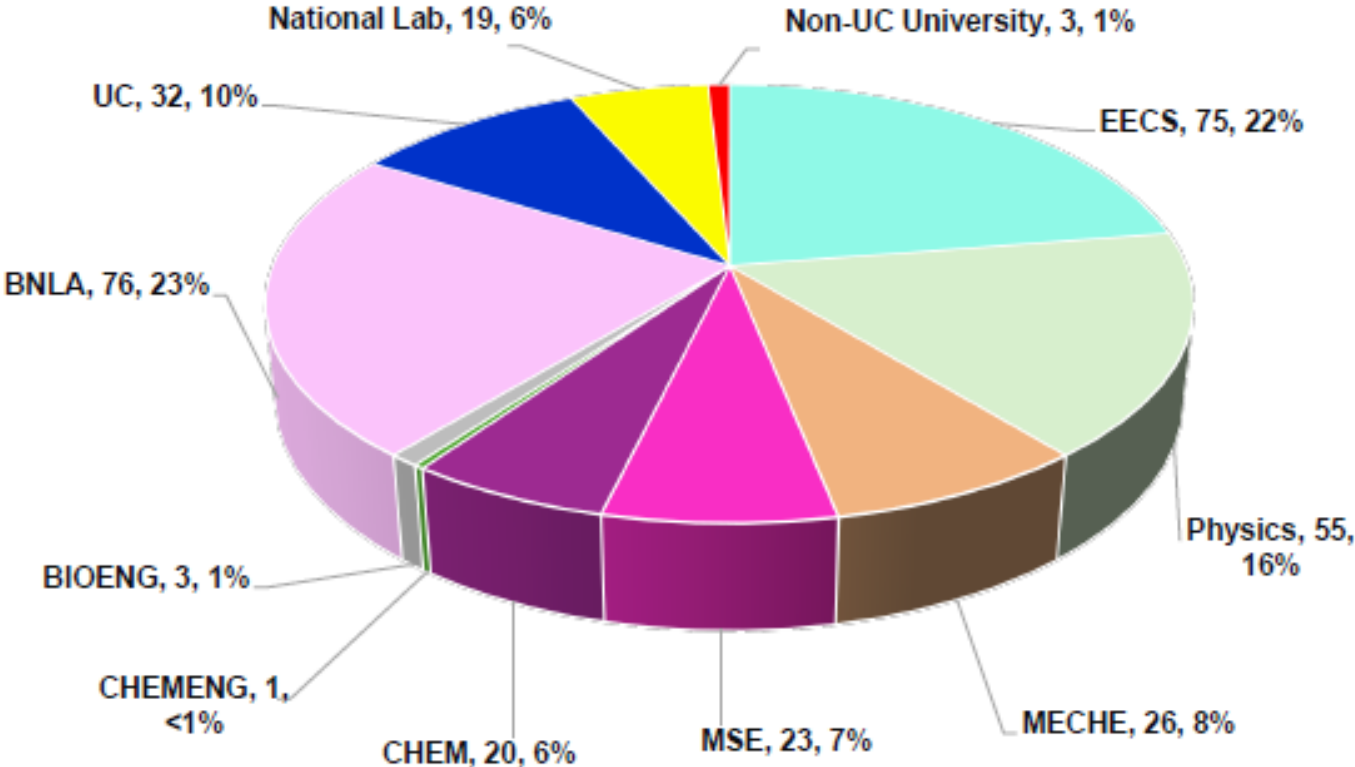
- Membership Analysis / Financial Status
 - FY 25 Recharge Rates

- New Equipment / Capabilities
 - Reality – here install underway – N2 generator
 - Reality – scheduled for delivery – Lam, CMP
 - Quote Requested for ME Commons Funded 200mm Epi

- Staff Summary – and The Hand Off

- Michael's Initial Analysis and Comments

Lab Members by Department FY 24 Total = 333

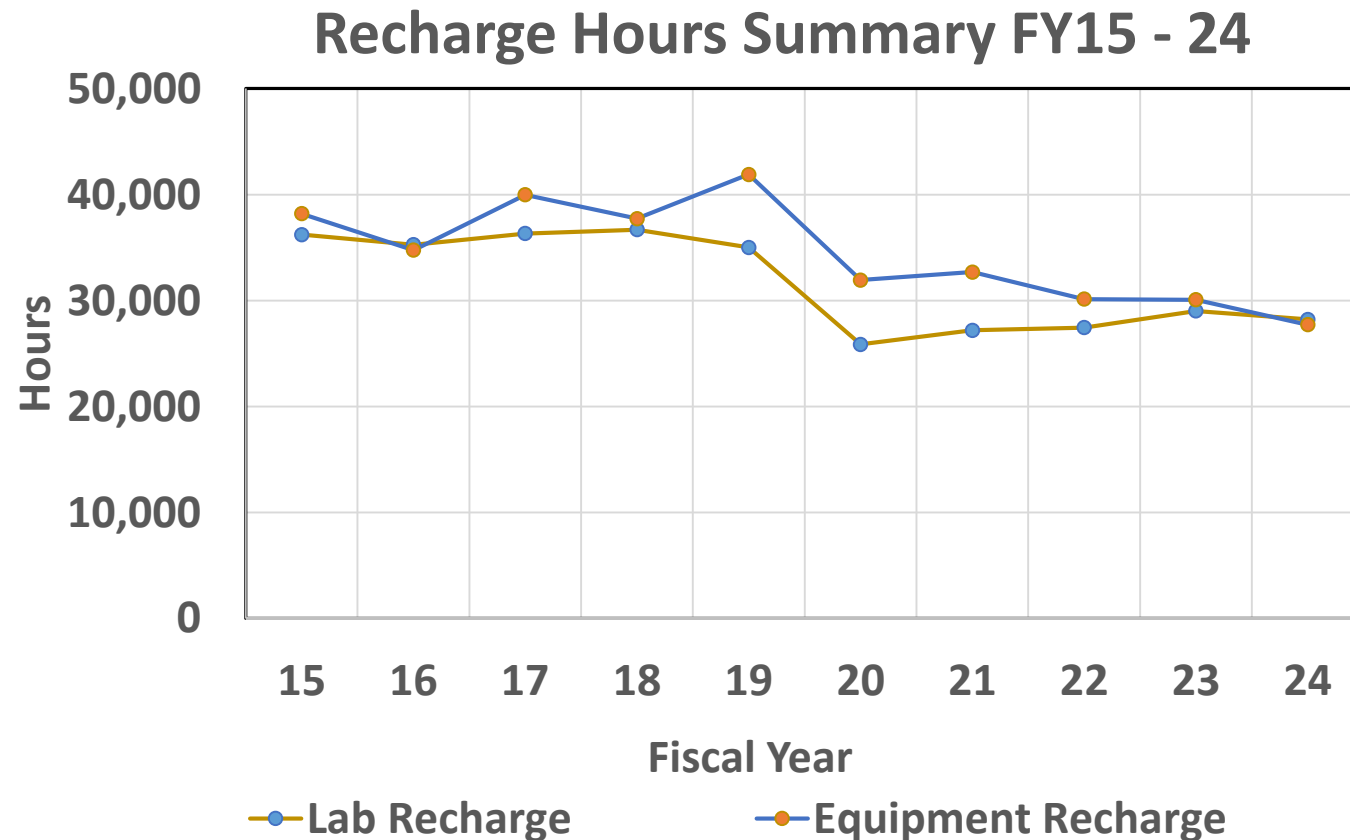


Fiscal Year	2018	2019	2020	2021	2022	2023	2024
Total	382	376	342	304	329	343	333
UCB	257	241	217	191	189	194	203
Commercial	73 (19%)	84 (22%)	73 (21%)	72 (24%)	82 (25%)	88 (26%)	76 (23%)
All Academic	309	292	269	232	247	255	257
External	125 (33%)	134 (36%)	125 (37%)	113 (37%)	140 (43%)	149 (43%)	130 (39%)

Lab Members Historical Analysis

FY	2017	2018	2019	2020	2021	2022	2023	2024
Total	370	382	376	342	304	329	343	333
UCB	252	257	241	217	191	189	194	203
Ext Acad	49	52	51	52	41	58	61	54
BNLA	69	73	84	73	72	82	88	76
EECS	125	114	111	94	79	71	69	75
Mech Eng	46	58	52	41	31	28	24	26
Physics	36	41	35	36	41	49	55	55
MSE	16	20	23	22	18	18	19	23
BioEng	1	1	0	3	2	5	3	3
Chem/ChE	27	23	20	21	18	17	18	21

Membership and Activity is Stable - but still below pre-pandemic level



The NanoLab 2024

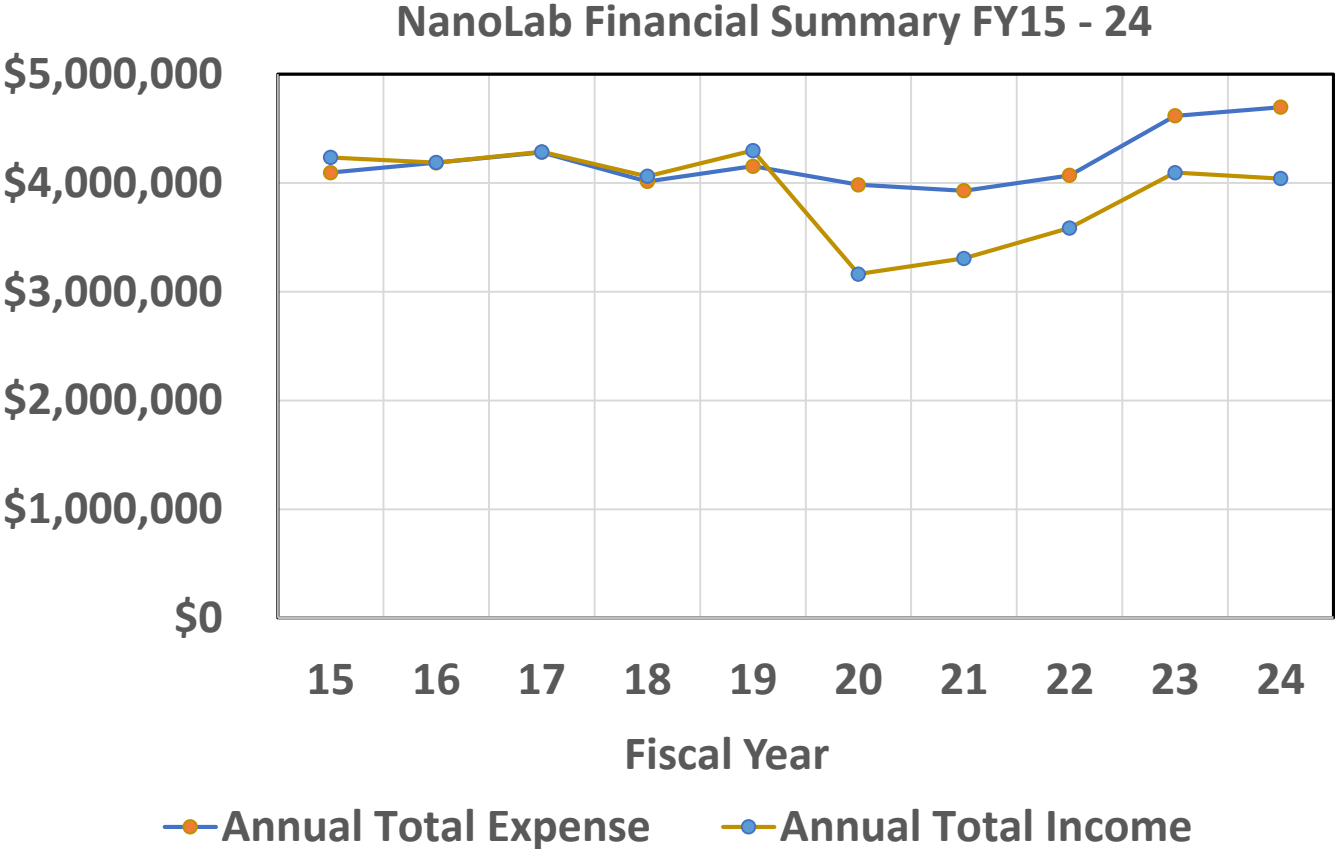
The Top 20 and Academic vs BNLA

Top 20 PI by Dept Δ '23			Financial Overview		Δ '23
EECS	6	↓1	All Academic	\$1.67 M	- \$10K
Mech Eng	1	↓1	Top 20 Academic	\$1.06 M	- \$ 29 K
Physics	6	↑2	All BNLA	\$2.15 M	+ \$40K
MSE	2	↓1			
Chem/ChE	3	↑1	Top 10 Academic	> \$45K	+ \$5 K
UCD EE	1	0			
UCSF BioE	1	0	Top 10-20	> \$20K	\$0 K

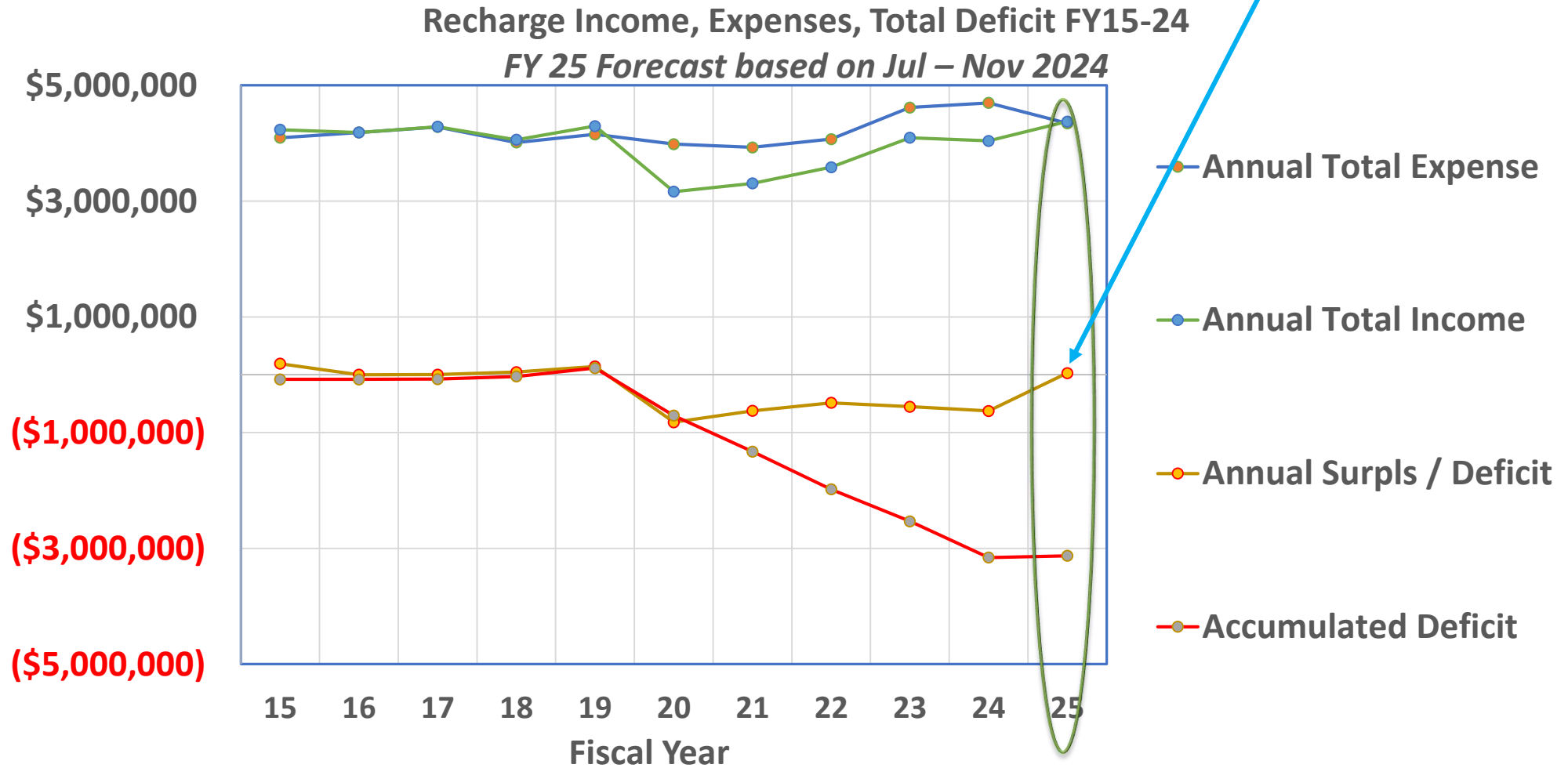
Best Regards to: Connie Chang-Hasnain, Vivek Subramanian, Eli Yablonovitch,
Xiang Zhang, Ramesh Ramamoorthy, Lane Martin, Tsu-Jae King Liu

Welcome: Alp Sipahigil, Boubacar Kante, Zakaria Al Balushi, Yuan Cao, Mengjie Yu

Year to Year Income Vs Expenses: Income Flat, Expenses continue to rise



Income Vs Expenses: A Deficit + **An Encouraging Forecast**



Rates , not caps, were increased at the beginning of FY25 (July 1, 2023)

Caps, not rates, will be increasing for 2nd half of FY 25 (Jan 1, 2025)

Income Vs Expenses: The Whole Picture

NanoLab Expenditures, All Fund Sources						
FY24						
Expense Category	Operations (61821)	Surcharge/ Overhead (60050)	Capacity Fee (66350)	EE143 (50772)	Equip Dep (76001)	Other Development Support
Salaries and Benefits	\$3,024,295	\$862,793	\$245,180	\$32,725	\$0	\$30,475
Supplies and Expenses	\$1,657,090	\$1,494	\$599,301	\$0	\$167,097	\$4,582
Totals:	\$4,681,385	\$864,287	\$844,481	\$32,725	\$167,097	\$35,057
Grand Total, All Funding Sources:	\$6,625,031					
Percentage of Grand Total:	70.7%	13.0%	12.7%	0.5%	2.5%	0.5%

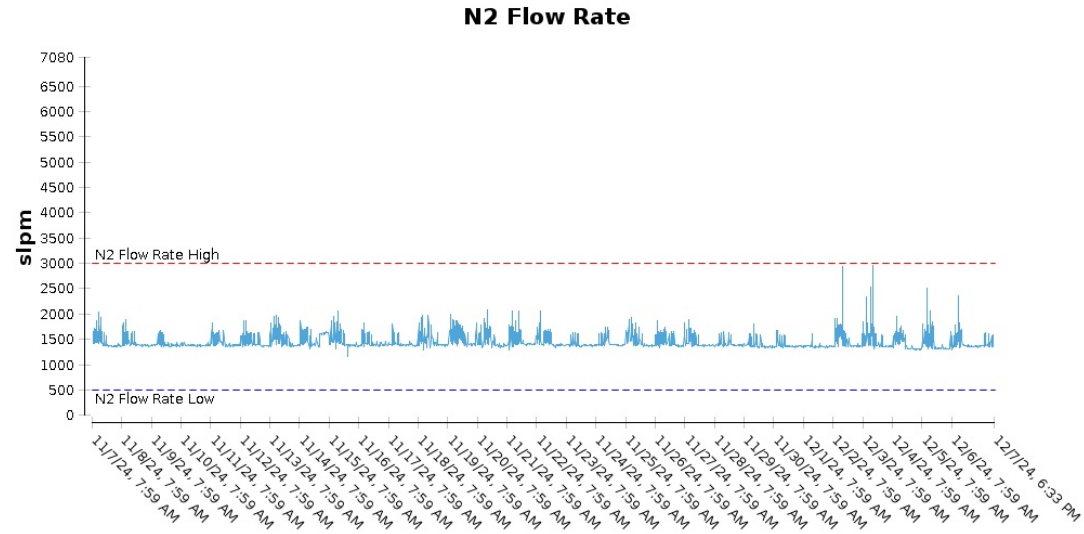
BNLA isn't just bringing in half the Operations Fund

– Surcharge and Capacity Fees are carrying 1/3 of all staff and >1/3 of S&E

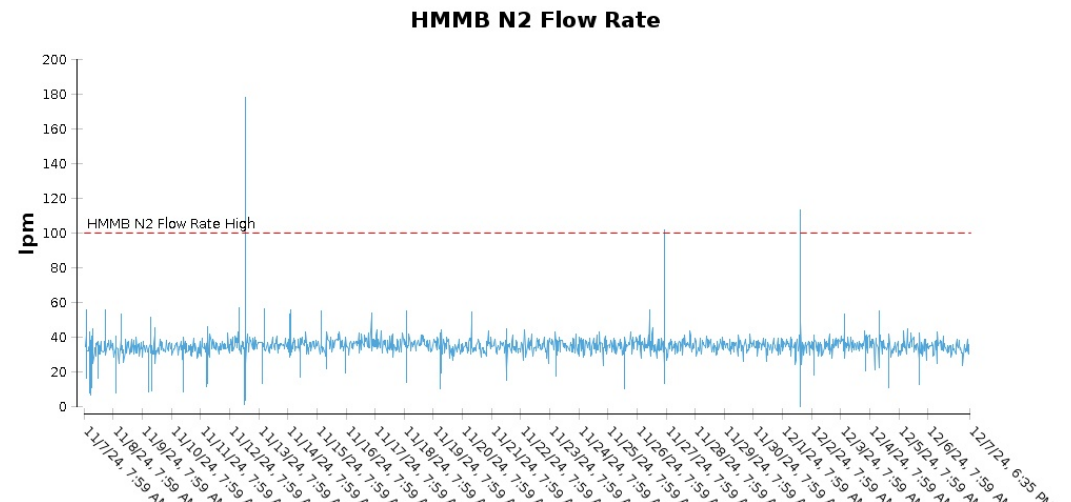
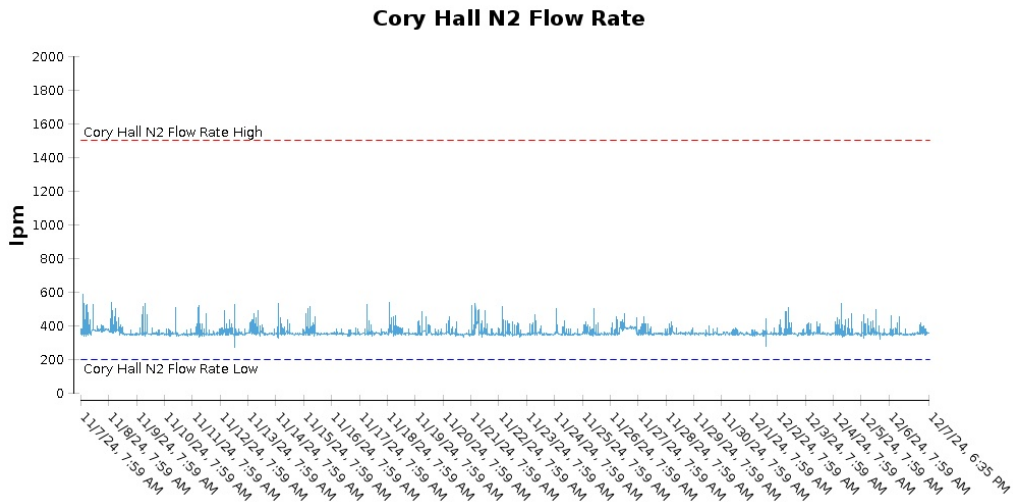
NanoLab Recharge Rates FY '25 vs FY '24	Academic			Affiliate		
	FY24	FY25	Δ	FY24	FY25	Δ
Access Fee / Month	\$98.00	\$101.00	3.1%	\$196.00	\$202.00	3.1%
General Lab Rate Use/Hour <i>(Includes sinks, microscopes, probe stations)</i>	\$52.80	\$55.20	4.6%	\$67.20	\$70.80	5.4%
General Lab Max/Month	\$1,500	\$1,600		\$2,800	\$3,000	
Tier 1 Equipment Rate Use/Hour <i>(Simple metrology, cpd, wirebond)</i>	\$27.00	\$28.20	4.4%	\$32.40	\$34.20	5.6%
Tier 1 Max/Month	\$300	\$400		NA		
Use Rate/Hour Over Max/Month	\$0.00	\$0.00	0.0%	NA		
Tier 2 Equipment Rate Use/Hour <i>(Advanced metrology, CVD, DRIE, contact litho)</i>	\$57.60	\$58.20	1.0%	\$70.80	\$74.40	5.1%
Tier 2 Max/Month	\$1,500	\$1,600		NA		
Use Rate/Hour Over Max/Month	\$6.00	\$6.60	10.0%	NA		
Tier 3 Equipment Use/Hour <i>(SEM, epi SiGe, DUV, ebeam litho)</i>	\$69.00	\$70.80	2.6%	\$158.40	\$162.60	2.7%
Tier 3 Cap	\$1,600	\$1,700		NA		
Use Rate/Hour Over Max/Month	\$19.80	\$21.60	9.1%	NA		
Staff Services	\$116.40	\$122.40	5.2%	\$116.40	\$122.40	5.2%

The NanoLab Drinks Nitrogen - Heavily

- NanoLab: 1500 lpm
\$340K in FY 24
100% cost increase since 2019



- Cory: 400 lpm and HMMB 40 lpm \$120K in FY 24



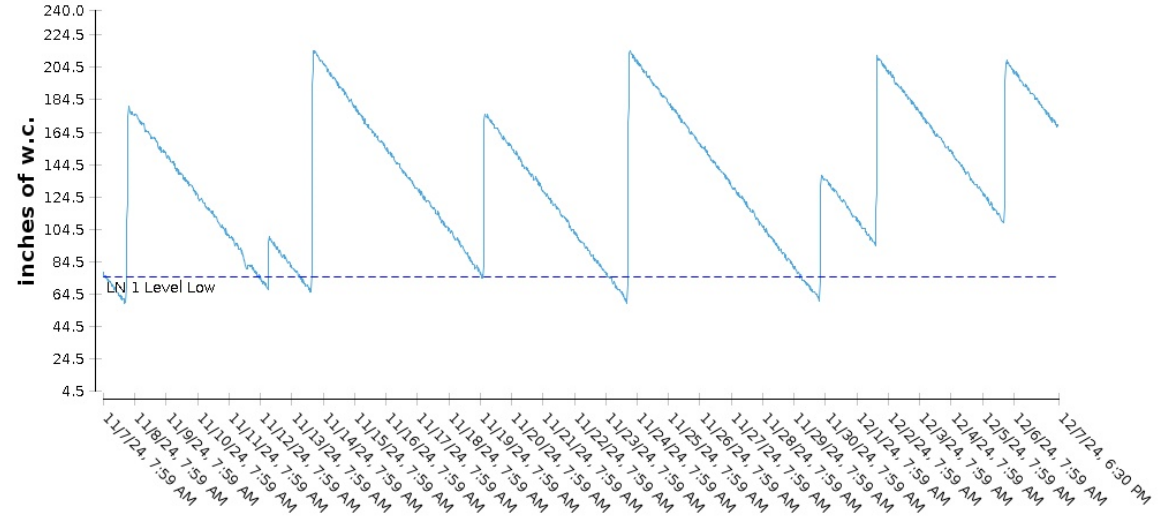
The LN2 Tanks are filled regularly

- Big Tank 9000 gallon
Filled ~ every 3-4 days

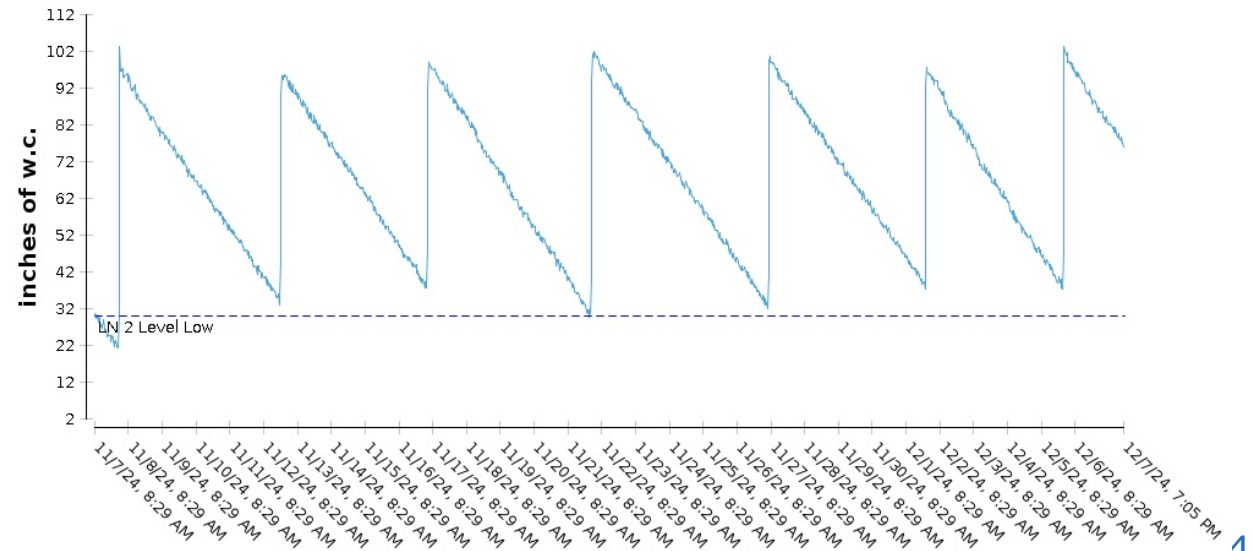


- Small tank 3000 gallon
Filled ~every 4-5 days

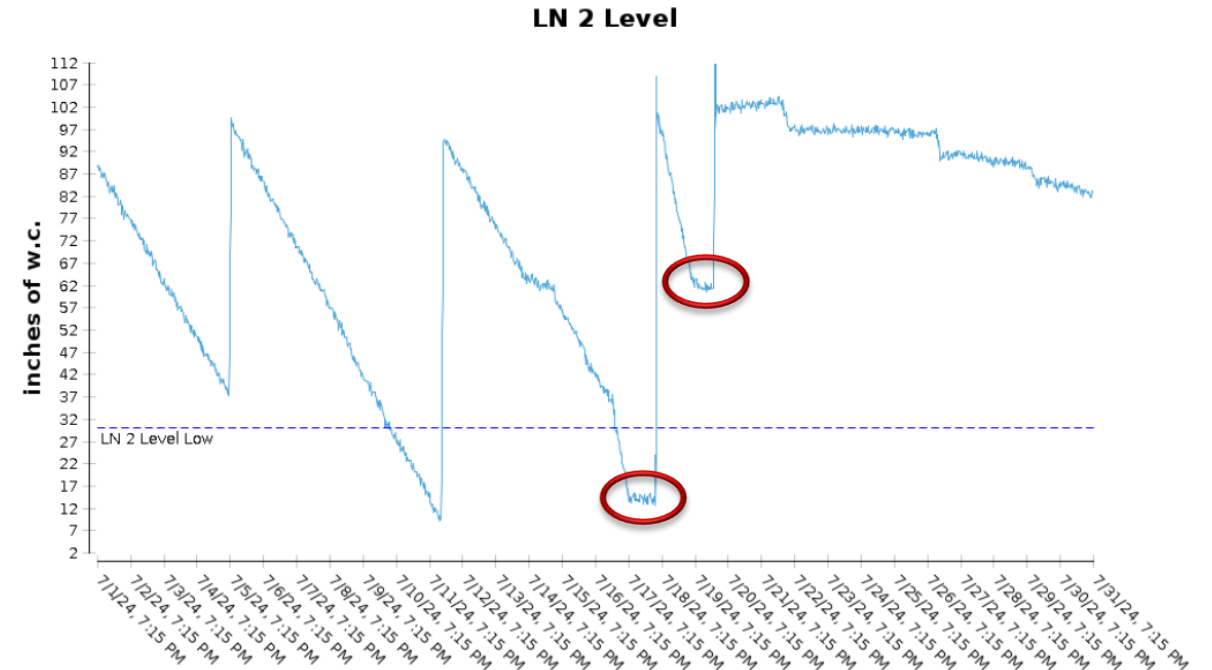
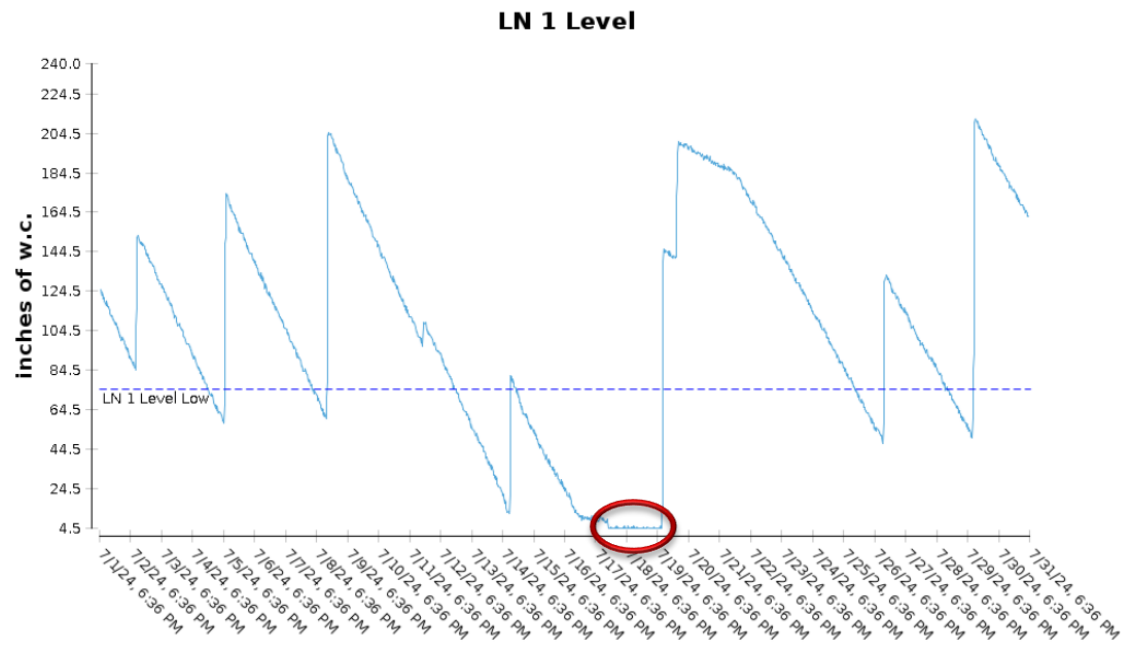
LN 1 Level



LN 2 Level

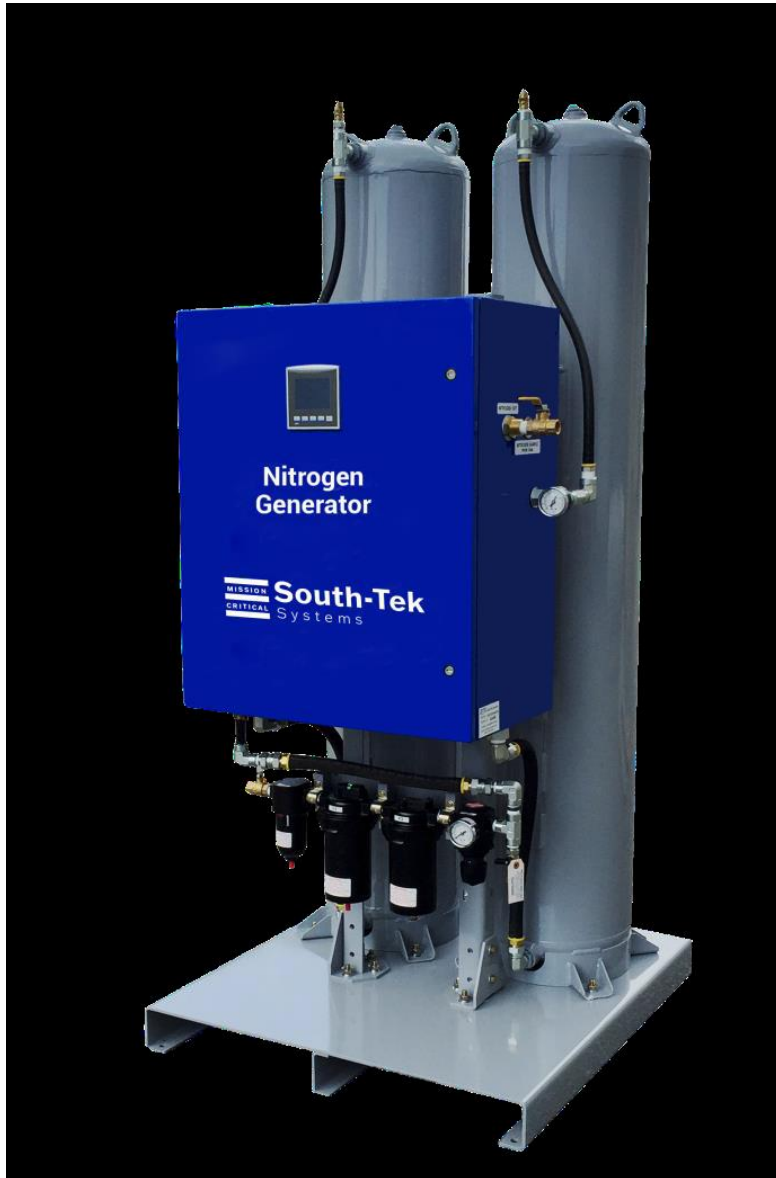


July 17 and July 19 2024 – the music stopped N2 was shut off to all three buildings for the 1st time in 40 years



N2 supplier declared force majeure due to equipment failures at multiple air separation plants.
Allocation - 30% of contract and price + 49%

NanoLab has purchased our first on site N2 generator



- Cost ~\$65K
- ~180 lpm of 99.99% \$25K savings/year
- ~325 lpm 99.9% \$45K savings/year
- ~450 lpm 99.5% \$63K savings / year

We will still have 5 9s process nitrogen
This N2 will be a separate piped system
for lower purity non-process needs.

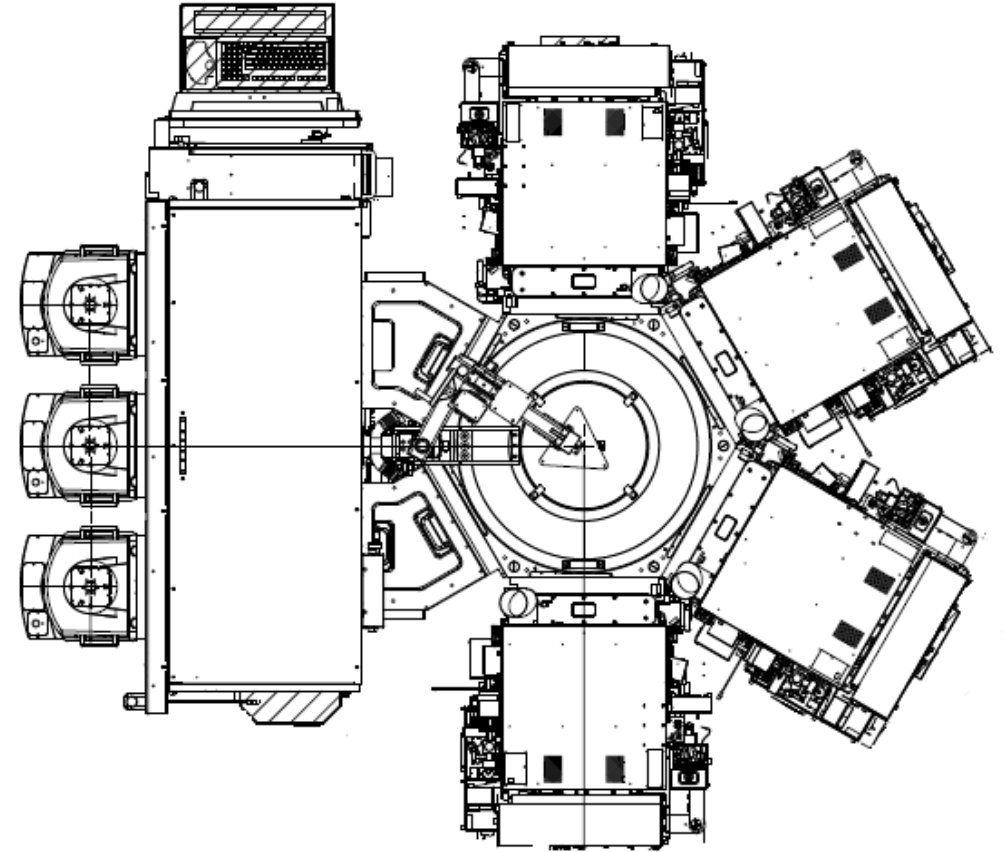
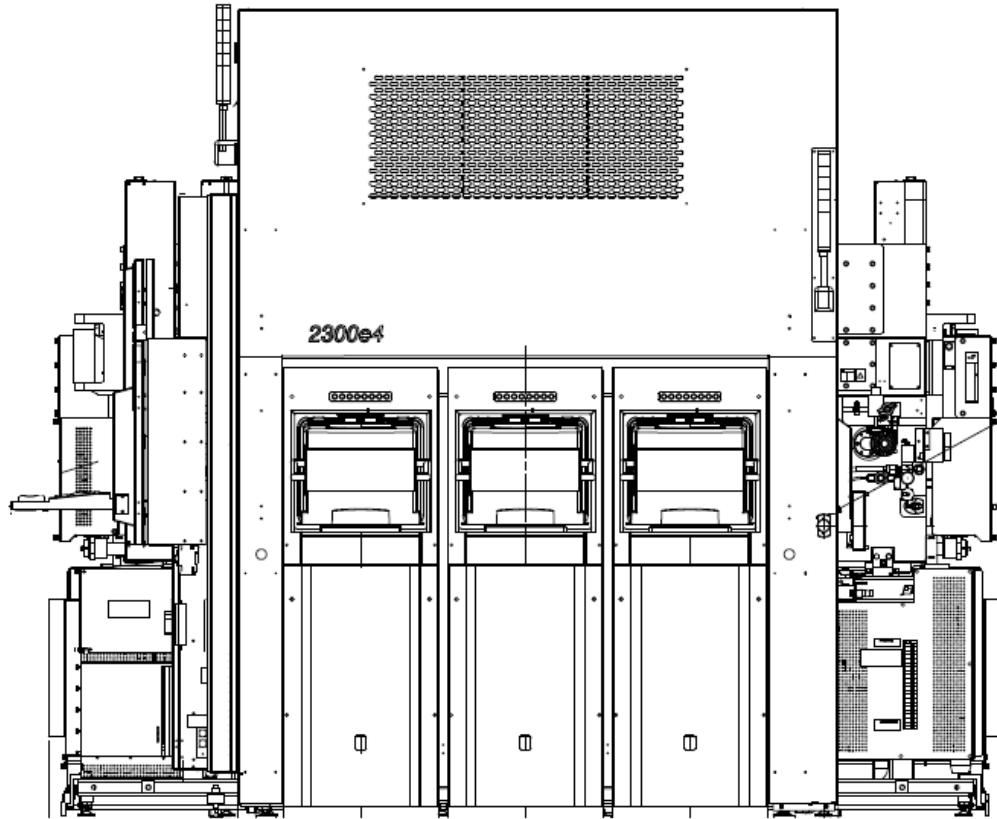
Install is underway
The unit will consume ~15 % of our CDA
This is our test system. Update next year

Lam 2300 v2

The Incoming 200mm Etch Platform for the UC Berkeley Marvell NanoLab



NanoLab is already 200mm capable for oxidation, LPCVD, lithography, metrology Etch is a Major Missing Piece for 200mm processing



Established hexapod design, 4 chambers, dual loadlock, powered load lock chlorine passivation in development

This compact cluster with 4 unique process chambers verified compatible with NanoLab Bay and Chase layout.

Lam 2300 v2 Provides NanoLab with TSV / ALE Next Gen Etch and ME-Commons CMOS equivalent nodes

	Chamber Type	Purpose	Special Notes	Materials of Interest	Cl2	BCl3	HBr	SF6	CF4	CHF3	C4F8	O2	H2O	N2	H2	NF3?	Ar	CH3F?	SiCl4	He
Chamber 1	Kiyo 45 TCW, pulsed W, ACC 9	Conductor Etch	ALE compatibility- pulsed plasma	Si/SiC/SiGe/Diamond	Y		Y	Y	Y			Y		Y	Y	Y	Y	Y	Y	Y
Chamber 2	KIYO45 TCW, pulsed W, ACC 9	Metal Etch	ALE compatibility- pulsed plasma	Al, Ti, W, Ru, Co, Nb	Y	Y	Y	Y	Y	Y		Y		Y	Y		Y			Y
Chamber 3	Flex 45	Dielectric Etch	200mm has 3Hz	SiO2, SiN, high-k dielectric				Y	Y	Y	Y	Y		Y	Y		Y			Y
Chamber 4	Syndion GP	TSV Deep Etch	AR ~	Steady state or BOSCH process capable (In-situ Ox HM ok)				Y	Y	Y	Y	Y		Y			Y			Y
ICS Loadlock add-on	Passivation	Post-Chlorine Passivation	NA on 200mm e4	Use O2 flash in etch chamber to minimize corrosion									Y	Y						

Top Level Configuration: 200mm 2300 v2 FID253207

KIYO45 conductor etch

KIYO45 metal etch

Flex45 dielectric etch

Syndion GP TSV Deep Etch

Dec 2023 - A Proposal

Dec 2024 - A Reality

Due to Ship March 10, 2025

Thank You! Lam Research

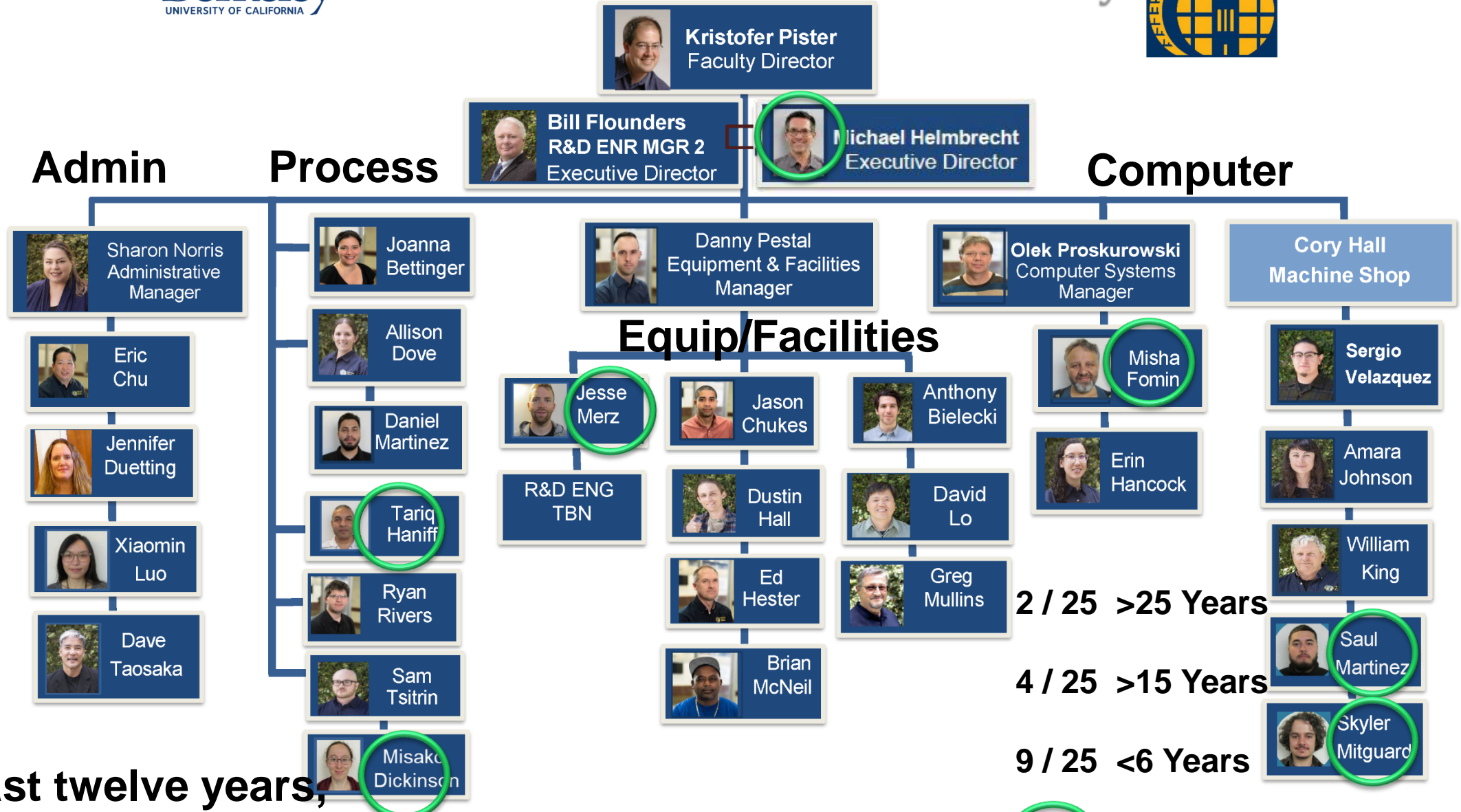
NanoLab is already 200mm capable for oxidation, LPCVD, lithography, metrology

CMP is a Major Missing Piece for 200mm processing



- ME Commons funded
 - Thank you Sayeef!
- Two 200mm capable CMP tools
 - Silicon/oxide
 - Metal
- Post CMP 200mm wafer cleaner
- Due June 2025





In the past twelve years,
17 staff have retired, 14 with >25 years of service.

2 / 25 >25 Years
4 / 25 >15 Years
9 / 25 <6 Years
7 <3 year

Summary

- Pandemic and inflation have created a significant deficit
 - Rate increases moderated and recovery allowed over several years
 - EECS activity recovering. ME does not show the same.
- NanoLab continues to expand services and capabilities as able
 - Transition to 200mm continues
 - We have wet process, oxidation, LPCVD, lithography, some metrology
 - Lam providing first etch
 - ME Commons providing CMP and Epi
 - We NEED improved ALD. We NEED 200mm ALD
 - Picosun thermal only - 2008
 - Cambridge with plasma – 2012 Both tools thanks to Clark Nguyen
- Staff turnover has been steadily addressed – and continues...

The NanoLab responds to your issues and works to control your costs.



Berkeley Fire Department Annual Tour

The shared lab model is alive and well thanks to your support.

Not Just BFD

EH&S

CARB

EBMUD

TGM 24/7

LN Tanks

OSHA

CoB

Thank you

Michael's Comments

Based on:

- Prior experience as academic member, BNLA
- A few face-to-face PI discussions
- 6 weeks of internal perspective

Rate Comparison – Most Academic Rate Increase Less than CPI

Nanolab Rate Comparison (Including Mid-Year Cap Increase)

Rate	FY2025 Academic Rate	FY2025 BNLA Rate	FY2025 BNLA/Acad Ratio	Academic CAGR	BNLA CAGR	CAGR Start Year	CAGR End Year
Access (\$/month)	101	202	2.00	1.8%	7.3%	FY2018	FY2025
Lab (\$/hr)	55.2	70.8	1.28	3.6%	5.9%	FY2018	FY2025
Lab Cap (\$)	1600	3000	1.88	1.9%	2.6%	FY2018	FY2025
Tier 1 (\$/hr)	28.2	34.2	1.21	4.3%	7.2%	FY2018	FY2025
Tier 1 Cap (\$)	400	NA	---	10.4%	---	FY2018	FY2025
Tier 2 (\$/hr)	58.2	74.4	1.28	4.1%	5.1%	FY2018	FY2025
Tier 2 Cap (\$)	1700	NA	---	2.8%	---	FY2018	FY2025
Tier 2 Overage (\$/hr)	6.6	NA	---	2.1%	---	FY2018	FY2025
Tier 3 (\$/hr)	70.8	162.6	2.30	2.4%	9.8%	FY2018	FY2025
Tier 3 Cap (\$)	1700	NA	---	1.8%	---	FY2018	FY2025
Tier 3 Overage (\$/hr)	21.6	NA	---	1.7%	---	FY2018	FY2025
Staff	122.4	122.4	1.00	5.4%	5.4%	FY2018	FY2025
CPI (West, Large Cities)			---	3.9%	---	Oct-18	Oct-24
CPI (West, Large Cities)				4.9%		Oct-20	Oct-24
Resident Tuition/Fees			---	3.00%	---	FY2018	FY2024
GSR Salary (Tier 1)			---	11.10%	---	FY2020	FY2024

- Nanolab rate increases compared to Tuition/Fees, GSR wages, and CPI
- Heavy-use members: capped + overage
 - Below CPI by 1-2%
- Light-use members: hourly rates
 - ~CPI
- Affiliate members are increasingly supporting the NanoLab
 - Rates are on par with other university laboratories

< CPI - 0.2%
CPI ±0.2%
+0.2% < CPI < +1%
CPI > +1%

All Members		Light-Use Members	
Heavy-Use Members		Comparisons	

Large Research Proposals

- ME Commons ramping up – includes direct support for NanoLab staff for equipment installation and interns (1.4 FTE staff, 1.0 FTE student staff)
- Increased activity on CHIPS Act and other mechanisms
 - CARISSMA – Ceder & Javey
 - SEMI PFAS Reduction – Maboudian & Nguyen
 - NAPMP – Wu
 - CITRIS Plasma Tech Lab - Bayen, Chabert, Lieberman, Mesbah
- Nanolab support for proposal applications
 - Budgeting for equipment and facilities upgrades
 - Cost sharing
 - Equipment installation, staff support from surcharge and capacity fees
 - NanoLab lead equipment donations
 - Workforce development – potential tie into the NanoLab intern program
 - Contact Bill/Michael for direct staff support and program requirements
- Note: Victoria Steffes @ BRDO provides excellent support for various opportunities
 - See [CHIPS and Science Act Funding Opportunities](#) presentation

NanoLab Student Interns



MICHELLE



NHI



CHRISSI



LITHO

ALLISON + DANIEL



CATE

FACILITIES

DANNY



VANSH



TANVI



ETCH + DEP

RYAN



JORGE

- WIISER Year 1
- WIISER Year 2
- ME Commons
- Nanolab Ops

SINKS + STOCKING

JOANNA



JAYDEN

THIN FILM

SAM



THERMAL PROCESSING

TARIQ



SANCHAY



BEN



Machine Shop – A Critical Part of the NanoLab and More

- Facilities upgrades
 - Mechanical
 - Electrical
 - Plumbing
- Tool installations
- Equipment repairs
- Support for EECS, COE, and campus wide efforts

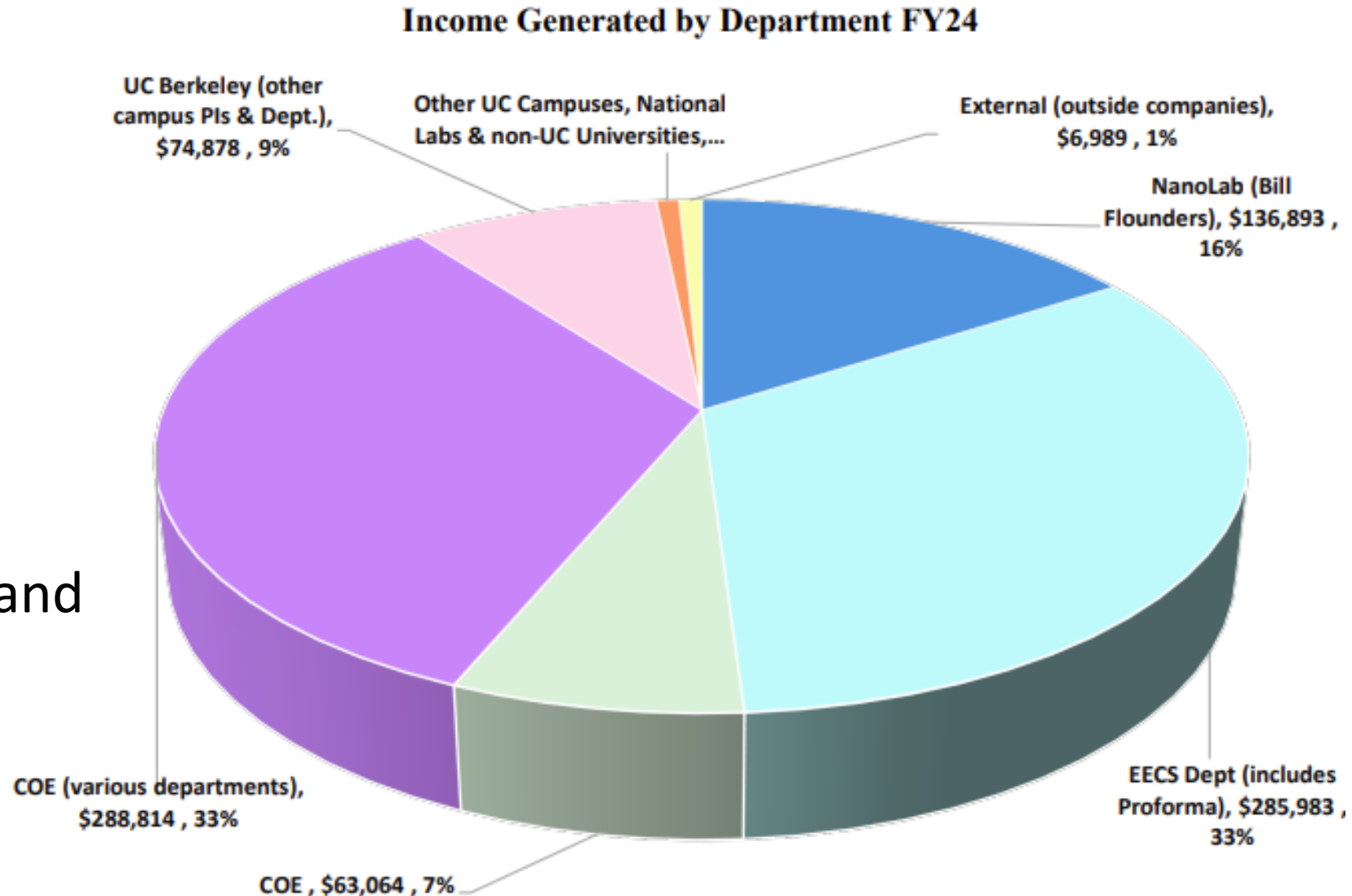
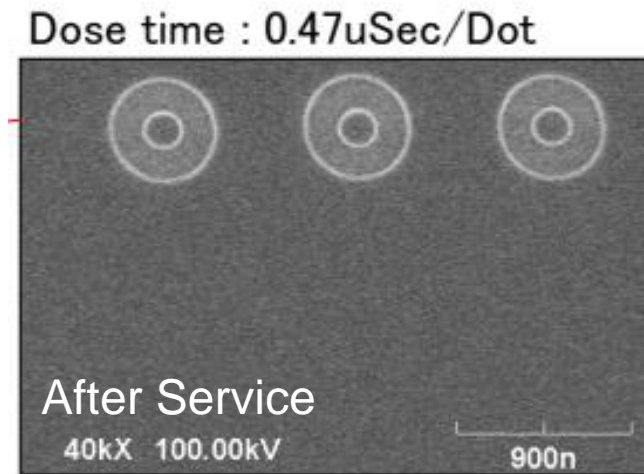
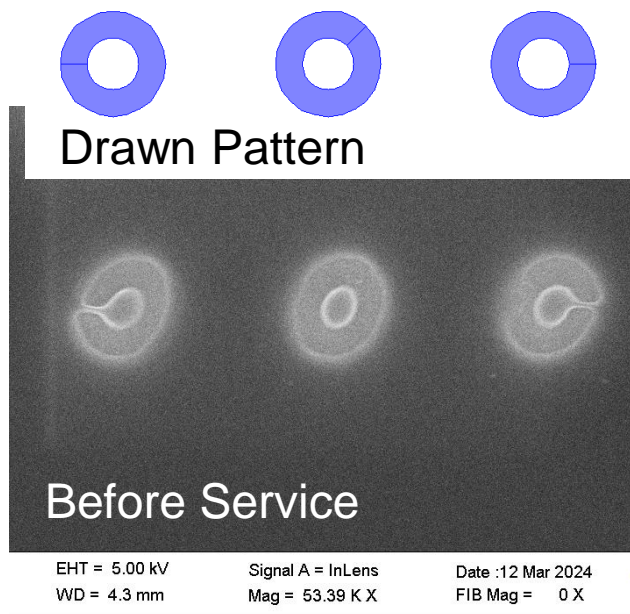


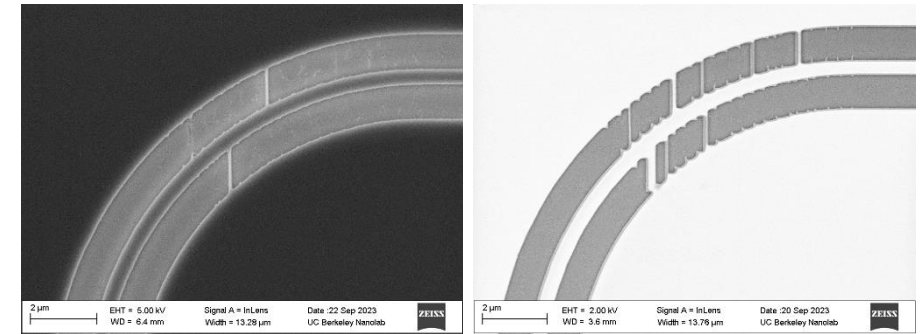
Figure 3.

Equipment: Crestec E-Beam Lithography

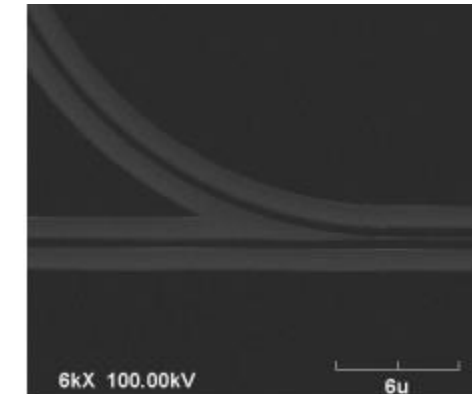
- Long standing issues with various patterns
- Prolonged and continued efforts by Nanolab staff (Allison Dove) and recent 2-week vendor visit have improved most issues
- Still has severe limits and performance issues for various patterns that affect some members



Before Service



After Service



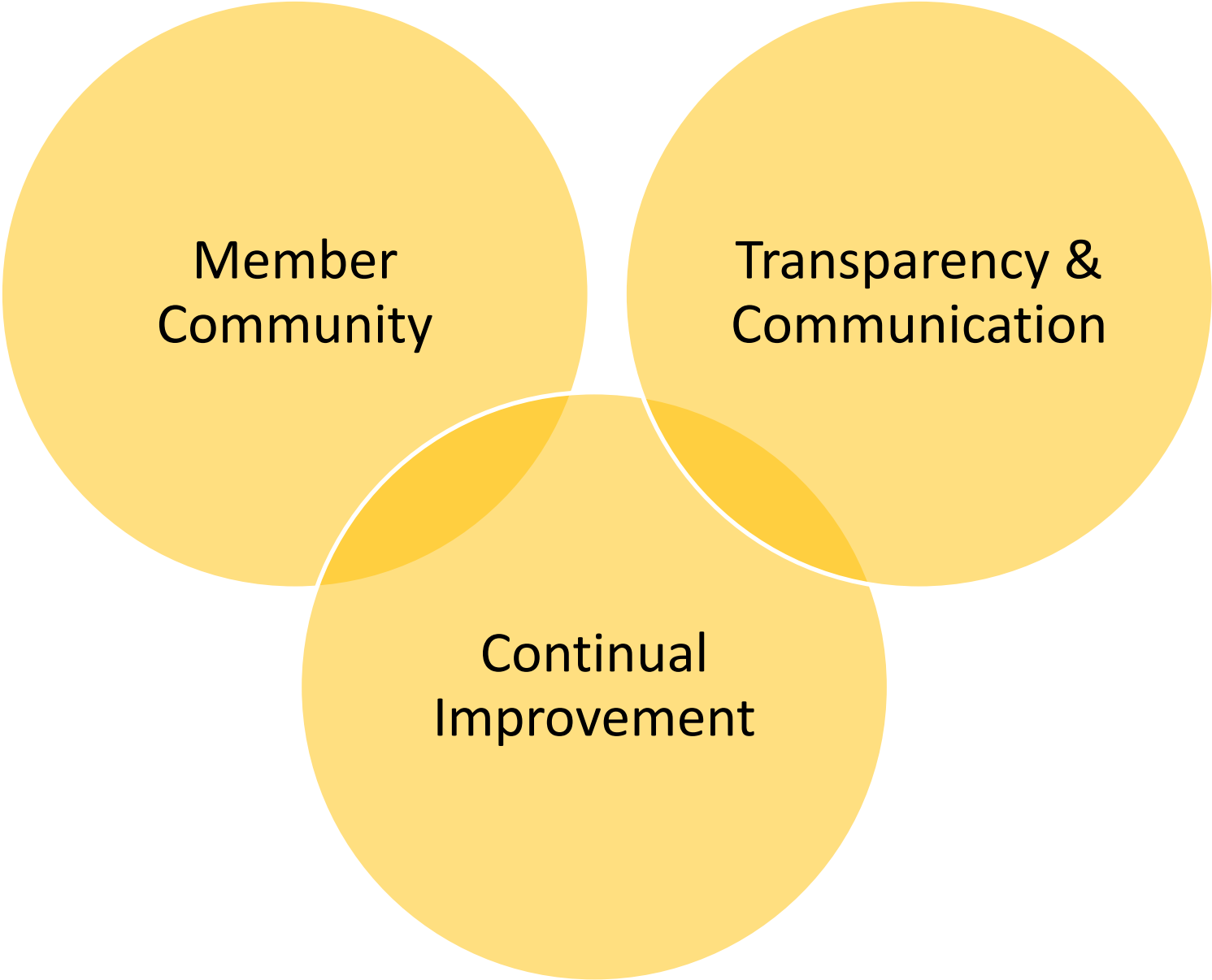
Equipment Wish List

- E-Beam Lithography Upgrades
 - Elionix (\$1.5M <100kV>)
 - Faster (2-40x) write times
 - Improved pattern fidelity
 - MAEBLE user feedback
 - It works as advertised
 - “Great solution for 3-5 years, but will start to see limitations then”
 - Raith (\$2M+ <100kV>)
 - Faster than Elionix
 - Better pattern fidelity
 - Has many features – top of the line system
 - “Gold standard of e-beam litho tools”

Equipment Wish List

- I-Line Lithography 8" Upgrades
 - MLA or ASML wafer stepper
 - Contact lithography
- Additional ALD chambers
- Composition analysis: TXRF, SIMS

Vision: Build on the Long Microlab and NanoLab History



Member Community

- Lab member meeting w/ Exec. Director introduction 1/22/2025
- Assisting new members
 - 11/21/2024: Lunch and Learn: Pattern Design and Mask Layout
 - Attendance: 14 in person, 16 online
- Under consideration
 - Regular 1-2x/month process and mask design reviews
 - Member driven/focused with some staff support
 - Bring back comments! (PI Request)

Ideas welcomed and encouraged!

Wand Comments from the Microlab

>>> 'lam2' comments from kpister -- Fri Jun 15 11:35:45 1990 <<<

I-line resist and oxide etching results

I seem to have had reasonable success etching oxide using I-line resist. The summary is 1.4 um resist survived a 2 um oxide etch using 500 W for 30 sec intervals. Etch rate looks just under .2um/min. The detailed info follows:

Initial processing, leaving me w/ 1.4 um densified LTO:

- .5 um thermal oxide
- .2 um snitc
- .7 um sdoltoe, densified
- <* other processing *>
- .7 um sdoltoe, densified

Resist:

spin 1.5 um I-line resist, shoot, develop, 120 C bake
150 C bake, 6 hours (1 hour suggested by Dave Hebert)

Etch:

Lam2, 500 W, 30 sec
remove, examine
repeat as necessary

HF etch:

5:1 BHF

Results:

I measured the PR thickness before etching and got 1.3um

wafer	# passes lam2	minutes in HF	/depth\ \w/ PR/	/depth\ \w/o PR/	= PR thickness
A3	0	5	2.7	1.4	1.3
A2	9	0	2.1	1.5	.7
3D14	6	2	2.9	2.1	.8
3D15	11	0	2.4	2.0	.3

(All depths measured w/ AS200)

Conclusions:

I blew through not only my 1.4 um oxide, but my .2 um nitride and .5um oxide passivation as well, on the latter 2 wafers, giving oxide etch rates a little above .2um/min.

Photoresist etch rate appears to be about .2um/min.

The photoresist on 3D14 developed some pinholes when dropped into the HF, but other than that it all looked fine.

>>> 'tylan16' comments from clark -- Mon Mar 15 16:33:46 1993 <<<

COMPLETE THE FOLLOWING INFORMATION:

Recipe used: dopy16a

dep time: 11 hrs. 35 min.

dep pressure:

dep temperature:

SiH4 flow rate:

expected thickness: 2 um

measured thickness: 19950 A and 19200 A (4 slots apart in middle boat)

comments: single wafer uniformity fairly good...~200 A for the 2 um thick depts.
wafer to wafer not so good, as you can see above

for undoped, remember to run coating run.

Clark

>>> 'lam2' comments from bill -- Tue Aug 1 17:11:55 1989 <<<

Nao. of wafers:4

Oxide or Nitride?cvd nitride on thermal ox

Thickness:~200 A

Standard recipe?No - modified step 4 only of oxide etch

Etch rate:to be determined (currently 20 - 50 A/sec and uniform)

If used other than standard recipe, enter parameters you used:

Pressure:

Time:2sec

Power: 700 W

>>> 'tylan16' comments from hmichael -- Wed Dec 15 14:22:53 1999 <<<

Dep rate for fuplya: 84.9A/min @ 605C

However, overwhelming majority of comments are “no comment”

Transparency and Communication

- Open-door policy to all – students, staff, and PI's
- The NanoLab is a data rich environment, culling actionable data in a presentable format is the biggest challenge
 - Student and PI ideas and perspectives wanted
 - Additional requests to meet for feedback will be sent to PIs
- Proposed: Strip-chart dashboard for easier analysis of equipment problems

Ideas welcomed and encouraged!

Continual Improvement

- Personal perspective as a former Microlab and NanoLab member
 - The Nanolab equipment capabilities, Mercury interface, operations, and process support have improved substantially over the decades
 - Like watching your children: being with them daily, you don't realize the growth until suddenly they are driving and off to college
 - NanoLab has made many creative modifications to tools to keep them running well past end of support dates from manufacturers
 - NanoLab finds ways to support vastly different process requirements on tools
- We will continue to search for creative ways to do more with less

Ideas welcomed and encouraged!

A Bit About Me

