Marvell Nanofabrication Laboratory

2014 Principal Investigators Meeting

Professor Ming C. Wu **Faculty Director**

Dr. Bill Flounders **Executive Director**

Agenda

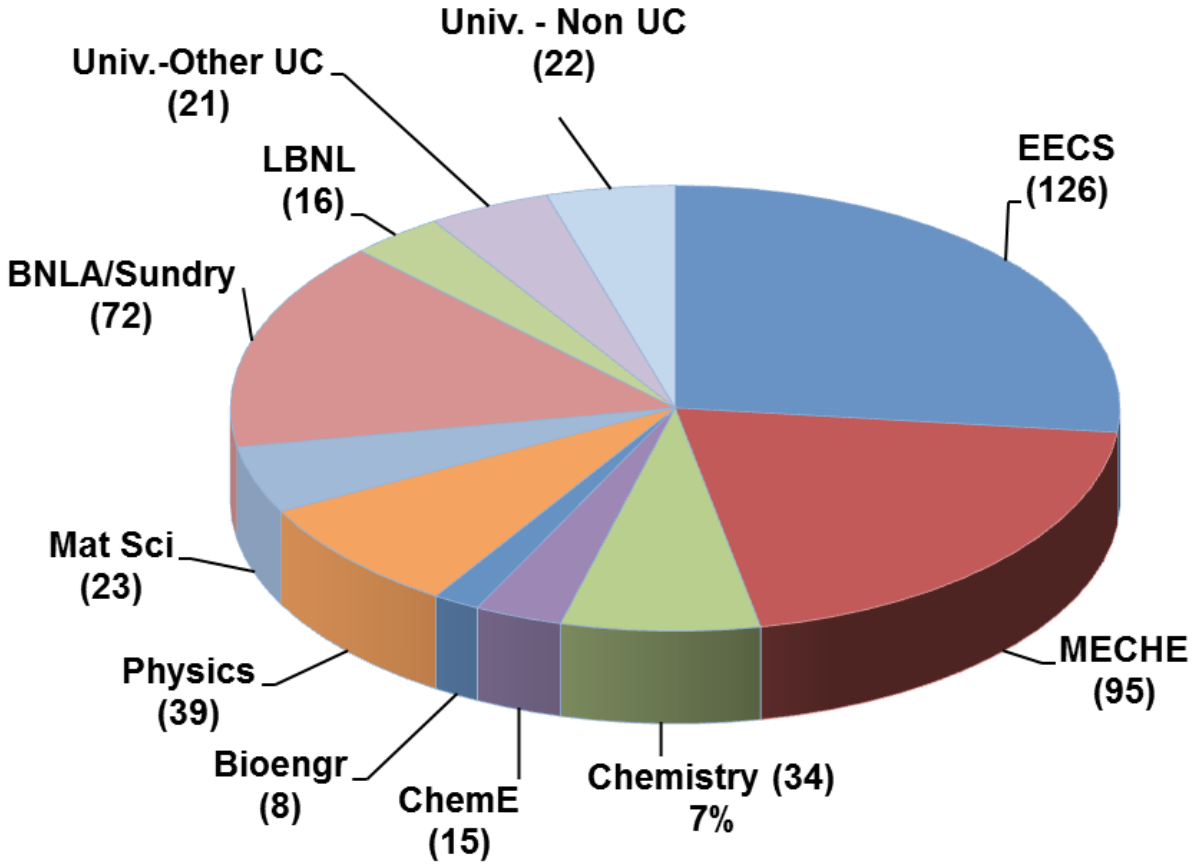
- NanoLab Staff Updates
- Membership Status and Annual Usage
- Quality Monitoring Program
- New Equipment / Capabilities
- FY 14/15 Rates Overview
- Potential One Time Support from VCR

Staff Updates

- WELCOME Neal Melton (Mar 2014) - Admin Manager
  - Congratulations Rosemary Spivey Retiring After (5+29) Years
- WELCOME Steven Scott (May 2014) – Financial Services
  - Congratulations Nancy Peshette Retiring After 13 Years
- WELCOME Greg Mullins (Nov 2013): Litho Eqpt Specialist
  - Congratulations Evan Stateler Retired After (12+19) Years
- Congratulations Sia Parsa – move to Noel Technologies

Lab Members by Department FY 13 Total = 471

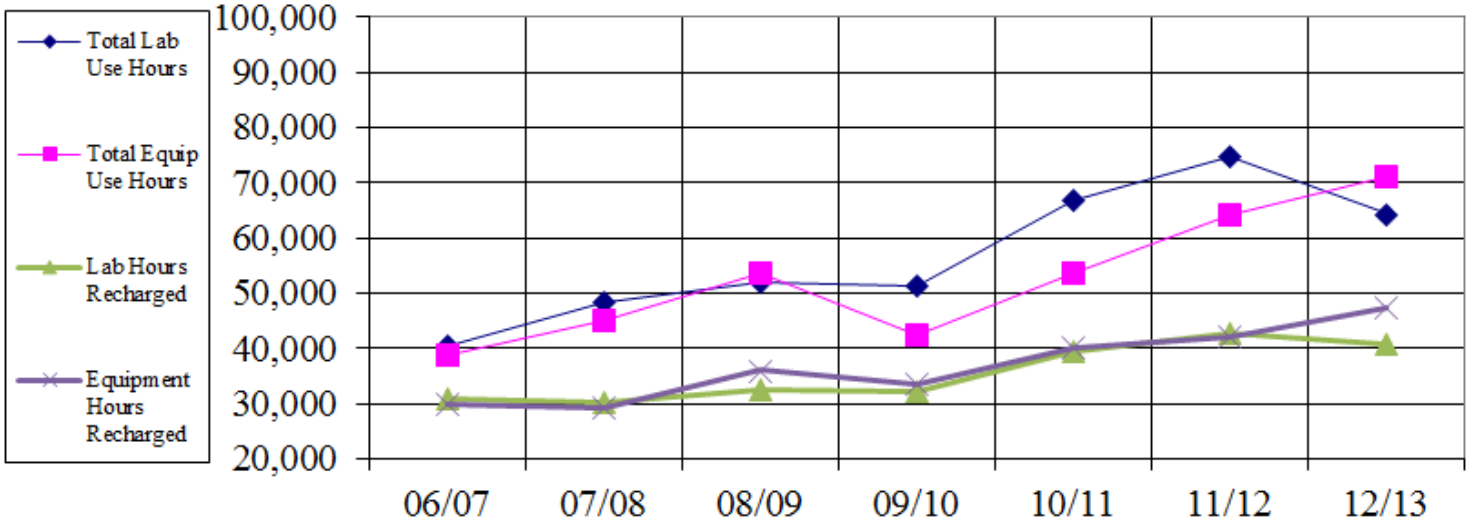
Membership is strong and stable



2013	471	
UCB:	340	
External:	131	(28%)
2012	497	
UCB:	372	
External:	125	(25%)
2011	474	
UCB:	353	
External:	121	(26%)
2010	469	
UCB:	370	
External:	99	(21%)

The NanoLab is Busy

4.5 – 7.4 people per hour 24/7



Growing gap between Use Hours and Recharged Hours.

Unclear if this trend is "real". As a student reaches the cap, they become careless about logout and disabling equipment
FY13 – Students reminded to log out
FY14 – not yet complete – 1st year with 25% overcap fee

Quality Monitoring Program

- The Microlab has had a “Baseline Monitor” effort for more than 10 years. Grew out of the CMOS Baseline
- Select processes are run by process staff on a regular basis and results are posted at NanoLab website
- This effort has been expanded to include more equipment, track etch selectivity, include etch images
- Selectivity monitoring requires patterning; images require SEM time.

QM Tools and Schedule

QM Tool Breakdown	CORE = 1x/month	A = Every Other Month	B = Other Every Other Month
	T1	T9	T10
	T2	T11	T12
	T5	Lam7	Lam6
	T16	Picosun	STS-Oxide
	T17	AIN1/2/3	Cambridge
	Technics-c	CHA	Oxford2
	Primaxx	Tescal	PQECR
	Centura-MXP	SVGCOAT3	
	Centura-MET		
	Lam8		
	STS2		
	MRC944		
	SVGCOAT1		
	SVGCOAT2		
	GCAWS6		
	ASML300		
	SVGDEV1		
	SVGDEV6		

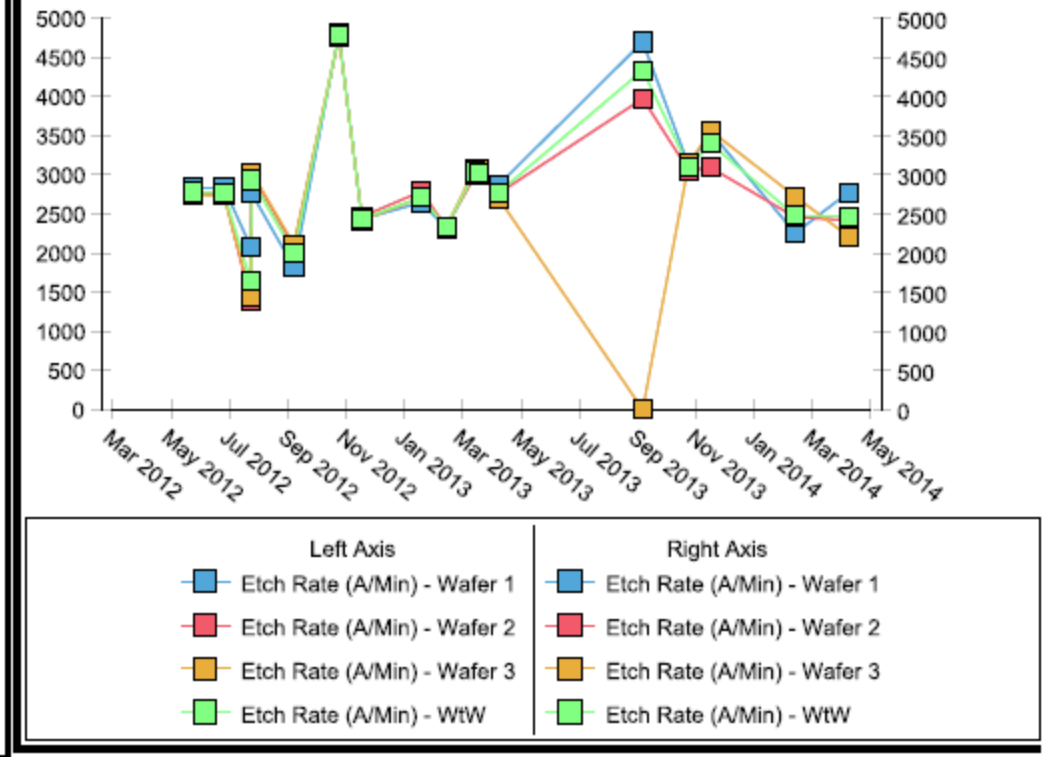
# Tools Monitored	Core	A	B
Thermal	5	2	2
Thin Film	1	6	3
Etch	6	1	2
Litho	4	1	0
Total	16	8	7

QM Sample: Etch Rate

7. Etching Systems - lam8 - 8001_POLY_ME

Process Conditions:

Run Date: 06/17/13
Etch Recipe: 8001_POLY_ME
Etch Time: 30 seconds
TCP RF Power: 300 Watts
Bias RF Power: 150 Watts
Cl2 sccm: 50
HBr sccm: 150
He (Torr): 4
Press (mTorr): 12



	Etch Rate (A/Min)			
	Wafer 1	Wafer 2	Wafer 3	WtW
4/8/14	2777	2420	2213	2470
2/11/14	2254	2458	2722	2478
11/15/13	3543	3091	3562	3399
10/23/13	3118	3055	3142	3098
9/5/13	4698.2	3973.3	0	4335.7

QM Sample: Uniformity

7. Etching Systems - lam8 - 8001_POLY_ME

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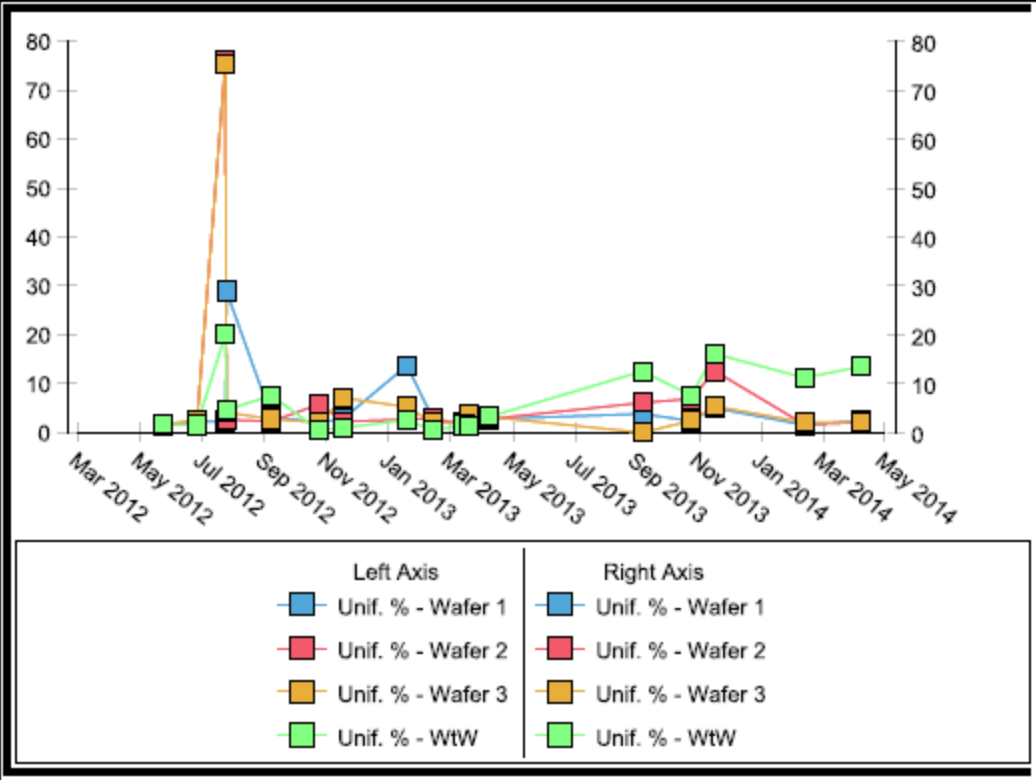

	Unif. %			
	Wafer 1	Wafer 2	Wafer 3	WtW
4/8/14	2.46	2.07	2.13	13.5
2/11/14	1.55	1.63	2.065	11.2
11/15/13	5	12.59	5.36	16.09
10/23/13	2.37	6.9	2.42	7.61
9/5/13	3.83	6.09	0	12.53

QM Sample: Selectivity

7. Etching Systems - lam8 - 8001_POLY_ME

Process Conditions:

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Etch Recipe: 8001_POLY_ME
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TCP RF Power: 300 Watts
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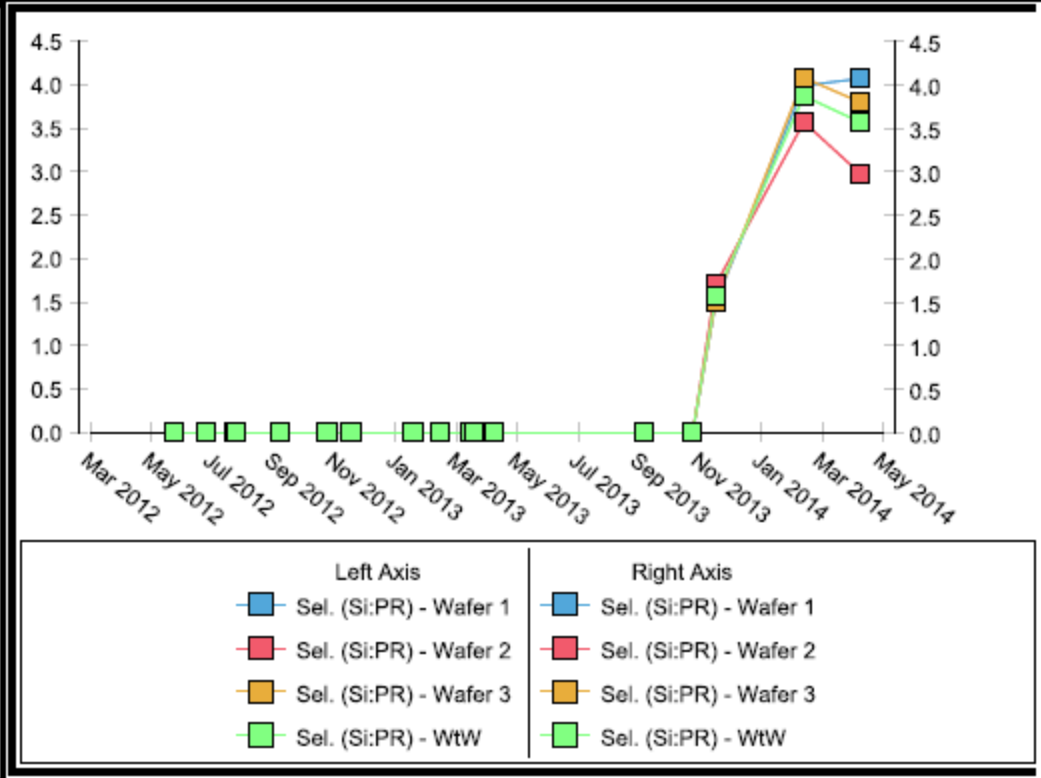
He (Torr): 4
Press (mTorr): 12



	Sel. (Si:PR)			
	Wafer 1	Wafer 2	Wafer 3	WtW
4/8/14	4.07	2.98	3.8	3.57
2/11/14	3.99	3.57	4.08	3.87
11/15/13	1.5	1.7	1.5	1.57
10/23/13	0	0	0	0
9/5/13	0	0	0	0

QM Sample: Latest Data with Image

7. Etching Systems - sts2 - Deep Silicon Etch

STS2 MONITOR

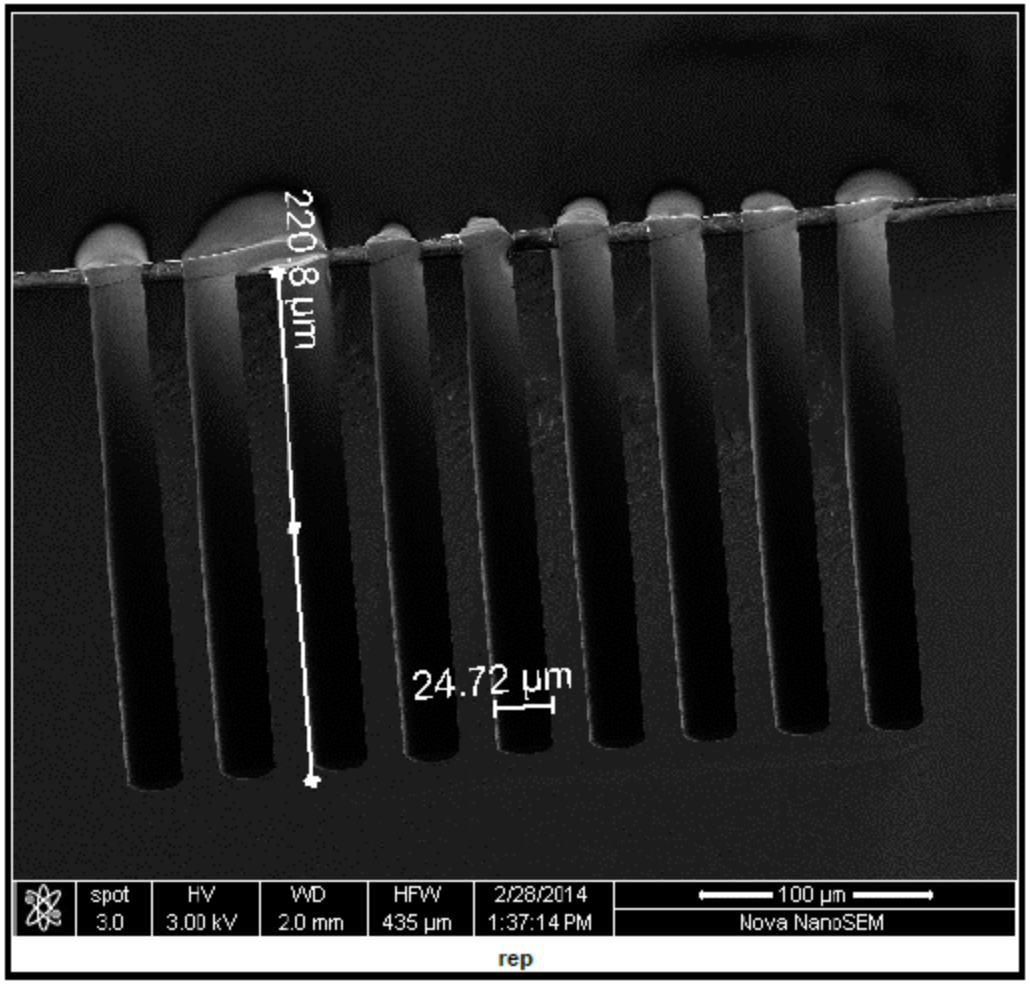
300 cycles

Etch:

10 sec
35 mTorr
130 sccm SF6
13 sccm O2
Coil 600W
Bias 20W HF

Deposition:

7sec
18 mTorr
85 sccm C4F8
Coil 600W
Bias none



	Etch Rate (nm/Cycle)	Selectivity (Si:PR)
	Wafer 1	Wafer 1
3/10/14	733	70

New Tools This Year

- Welcome “mrc944” : 4 target sputter system.
  - Congratulations “cpa” - Retiring After 28 years

- Welcome oxford-icp : dual plasma source III-V plasma etch
  - Congratulations “oxford” - computer/LL upgrade after 18 years

- Wecome ultek2: 3 crucible e-gun evap with custom cooled fixture
  - Congratulations “ultek”- 3rd major overhaul in 30+year history

- Welcome “yes-g500” : variable configuration O2 box plasma rxt
  - Congratulations “barrelreactor” is back and better than ever

Farewell cpa

- 4 target general use sputter deposition system

- FY13: 30 qualified members
11 faculty and 10 BNLA companies

- >2100 use hours FY12 and FY13

- <10% down until FY11 then
21% and 24% down FY12, FY13

Welcome mrc944

- Al/2%Si Al / Mn Ti W (Ni)
- Ar sputter pre-clean
- Cryo pump on LL and on main chamber
- Fully automated PLC system control
- Protected chain pallet transfer system
- Purchased with BNLA Funds

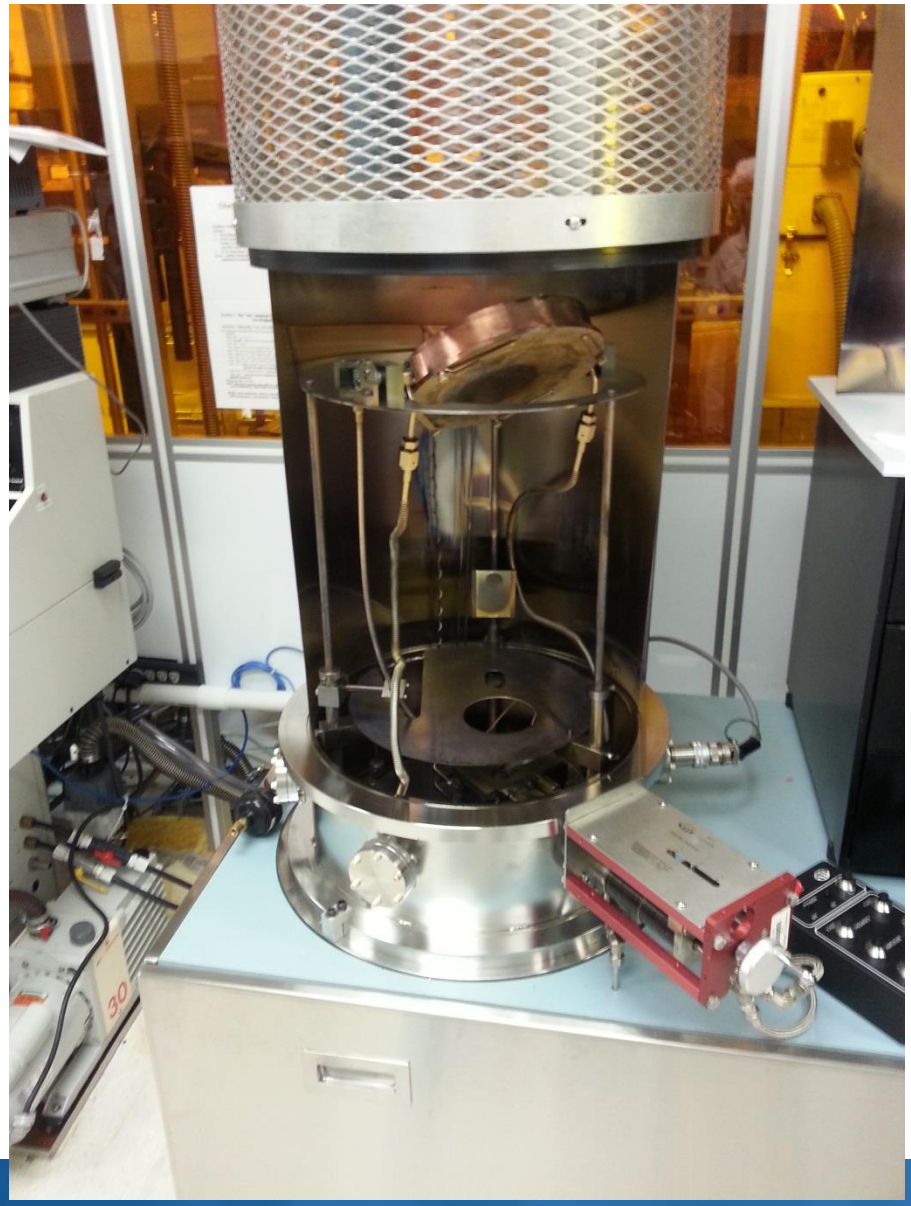
“ultek” transformed into “ultek2” NanoLab and Machine Shop Makeover

Before

After

ultek2

- 3-pocket e-beam with integrated QCM
- Custom cooled chuck: sample angle can be changed in-situ w/o breaking vacuum
- Full 6” coverage. ~12” throw
  Cool samples = good liftoff
- Thanks to EECS Prof Subramanian + BNLA Funds



oxford-icp

- Dual plasma source for III-V H2, CH4, HBr, Cl2, BCl3, SiCl4
- In-situ laser etch monitor
- DARPA funded
- Thanks to EECS Prof Chang-Hasnain

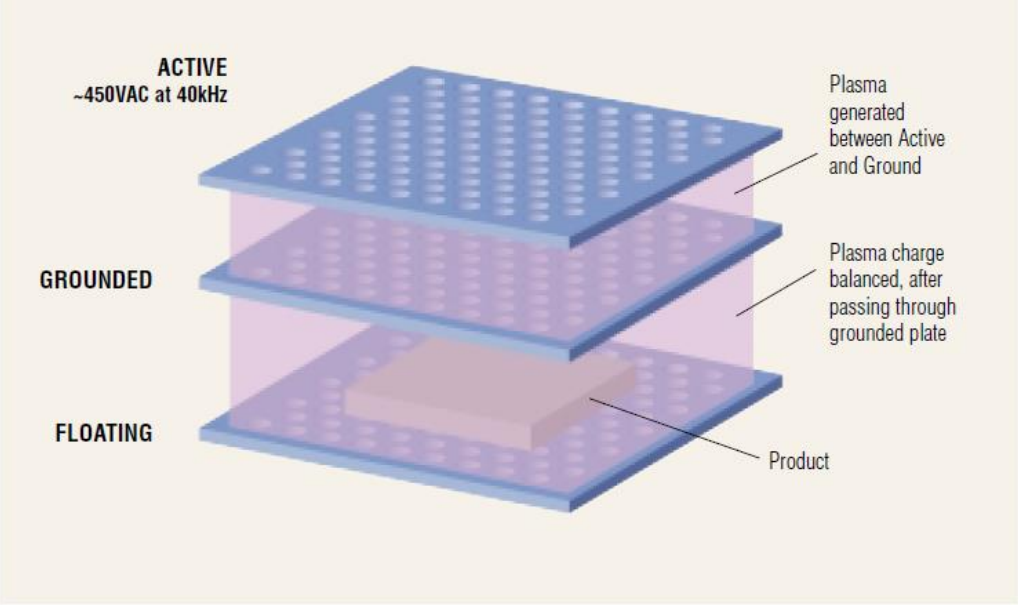
Microlab Barrel Reactor is now YES-G500

LFE | Tracerlab

A Division of Laboratory for Electronics, Inc.
2030 Wright Avenue, Richmond 3, California

Yes G-500

- Parallel plate plasma reactor with reconfigurable Electrodes. O2 or Ar. 500 W Downstream, barrel or RIE



Downstream Configuration

- Polymer modification and prebond cleaning
- Thanks to Mech Eng Prof Hayden Taylor

FY14/15 Academic Recharge Rates

Category	FY 2012/13	FY 2013/14	FY 2014/15	% change
Access Fee	$89.00	$91.50	$92.60	1.2%
General Laboratory Rate	$41.40	$43.20	$44.40	2.8%
General Lab Rate Max	$1,300.00	$1,300.00	$1,332.00	2.5%
Special Equipment Rate	$39.00	$40.80	$42.00	2.9%
Special Equip Rate Max	$1,500.00	$1,500.00	$1,540.00	2.7%
Special Equip Volume Rate	n/a	$10.20	$6.00	-41.2%
E-beam Lithography	$130.00	$111.00	$110.40	-0.5%
High Performance SEM	$60.00	$60.00	$60.00	0.0%
Staff Services	$72.60	$75.00	$78.60	4.8%

NanoLab Annual Cost Estimator

Will be posted at NanoLab Website

Marvell Nanofabrication Laboratory
University of California, Berkeley

NanoLab Annual Cost Estimator - Academic Recharge Rates

Access Fees	$82.60	per person per month	Monthly Total		Annual Total
How many researchers will require access in a typical month? (include PI if she/he requires access)	0	Monthly Cost:	$0.00	Annual Cost:	$0.00
General Lab Usage	$44.40	per hour			
How many estimated hours per month will each researcher above need to spend in the lab? *(Rate cap/maximum of $1332/member/month factored in) Lab Usage rate includes all sinks, most manual lithography*	0	Monthly Cost:	$0.00	Annual Cost:	$0.00
Special Equipment	$42.00	per hour			
How many estimated hours per month will each researcher above need on special equipment (equipment list at NanoLab website)? *(Rate cap/maximum of $1540/member/month factored in. Additional hours above cap*	0	Monthly Cost:	$0.00	Annual Cost:	$0.00
E-Beam Lithography (Crestec)	$110.40	per hour			
How many estimated hours per month will each researcher above need on the Crestec for E-Beam Lithography?	0	Monthly Cost:	$0.00	Annual Cost:	$0.00
Scanning Electron Microscopy	$60.00	per hour			
How many estimated hours per month will each researcher above need on the High Performance SEM?	0	Monthly Cost:	$0.00	Annual Cost:	$0.00
NanoLab Staff Services	$78.60	per hour			
How many estimated total hours of NanoLab staff time do you anticipate per month, if any?	0	Monthly Cost:	$0.00	Annual Cost:	$0.00
Estimated Total Annual NanoLab Cost:	$0.00				

FY14/15 BNLA Recharge Rates

Category	FY 2012/13	FY 2013/14	FY 2014/15	% change
Access Fee	$89.00	$91.50	$108.65	18.7%
General Laboratory Rate	$41.40	$43.20	$47.40	9.7%
General Lab Rate Max	$2,200.00	$2,200.00	$2,300.00	4.5%
Special Equipment Rate	$39.00	$40.80	$50.40	23.5%
E-beam Lithography	$130.00	$111.00	$124.20	11.9%
High Performance SEM	$60.00	$60.00	$72.00	20.0%
Staff Services	$72.60	$75.00	$78.60	4.8%

FY14/15 BNLA Membership Fees

	Yearly BNLA Fee		
Lab Members/Company	**Previous** (since 2001)	**Effective 7/1/13**	**Effective 7/1/14**
1	**$15,000**	**$17,500**	**$17,500**
2	**$25,000**	**$27,500**	**$27,500**
3 - 4	**$35,000**	**$37,500**	**$37,500**
5 – 6	**$50,000**	**$55,000**	**$55,000**
General Cap	**$1600**	**$2200**	**$2300**
Equip Cap	**None**	**None**	**None**

Staff Benefit and Campus Overhead Rates

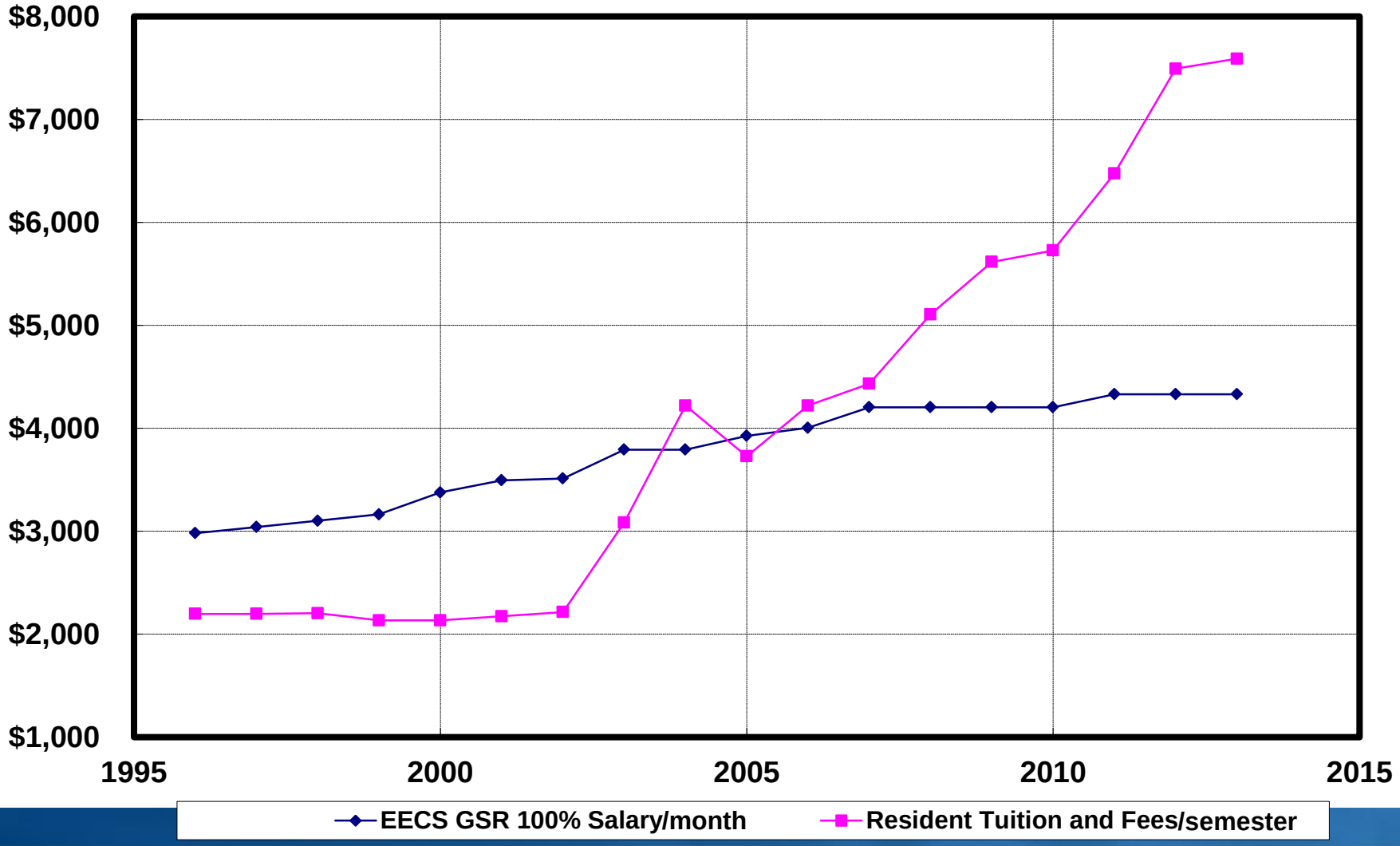
Benefit Rate Increase 13.5% in past 3 years

> 20% (almost double) expected over 6 years

Fiscal Year	2011	2012	2013	2014	2015	2016	2017	2018
Academic Benefit %				33.9	36.8	39.5	42.1	42.6
Staff Benefit %	28	33	38	41.5	44.6	47.6	50.5	51.3
Campus Overhead %	55.5	55.5	55.5	56.5	56.5	57	TBD	TBD

UC Fees and EECS GSR Salary

Tuition and Fee increases >> NanoLab rate changes



Potential VCR Investment in the NanoLab

- CITRIS Director Prof Costas Spanos is negotiating one time VCR investment in the NanoLab. Thank you Costas!

- $250K proposed in FY 15
- $250K add in FY16 if NanoLab secures match.

- FY15 funds would meet already defined needs:
  - lithography equipment stabilization
  - CMP relocation from Cory Hall
  - required TGM system upgrade

- FY16 funds directed by PI input and cost sharing

Summary

- Quality Monitoring Program Developed to improve equipment performance and researcher productivity

- Academic Rate Lab and Equipment Increases <3%
- Over cap rate decreased from $10/hr to only $6/hr

- NanoLab Staff fixed costs are steadily increasing
- PI GSR fees and University OH are steadily increasing
- NanoLab recharge rate increases are << than university increases
- NanoLab rate increases have focused upon external non-academic
  - BNLA Rate Increases 4 – 24%

Seven years ago…
we didn't have a floor to stand on

And today…
we're running out of floor space

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

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

Equipment investors in the NanoLab E3S, Chang-Hasnain, Dornfeld, King, Nguyen, Subramanian,Taylor, Howe, Pisano…
are especially recognized

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

UC Berkeley EECS Professor,
William G. Oldham

Thank you