



**Marvell
Nanofabrication
Laboratory**

2016 Principal Investigators Meeting

Professor Ming C. Wu

Faculty Director

Dr. Bill Flounders

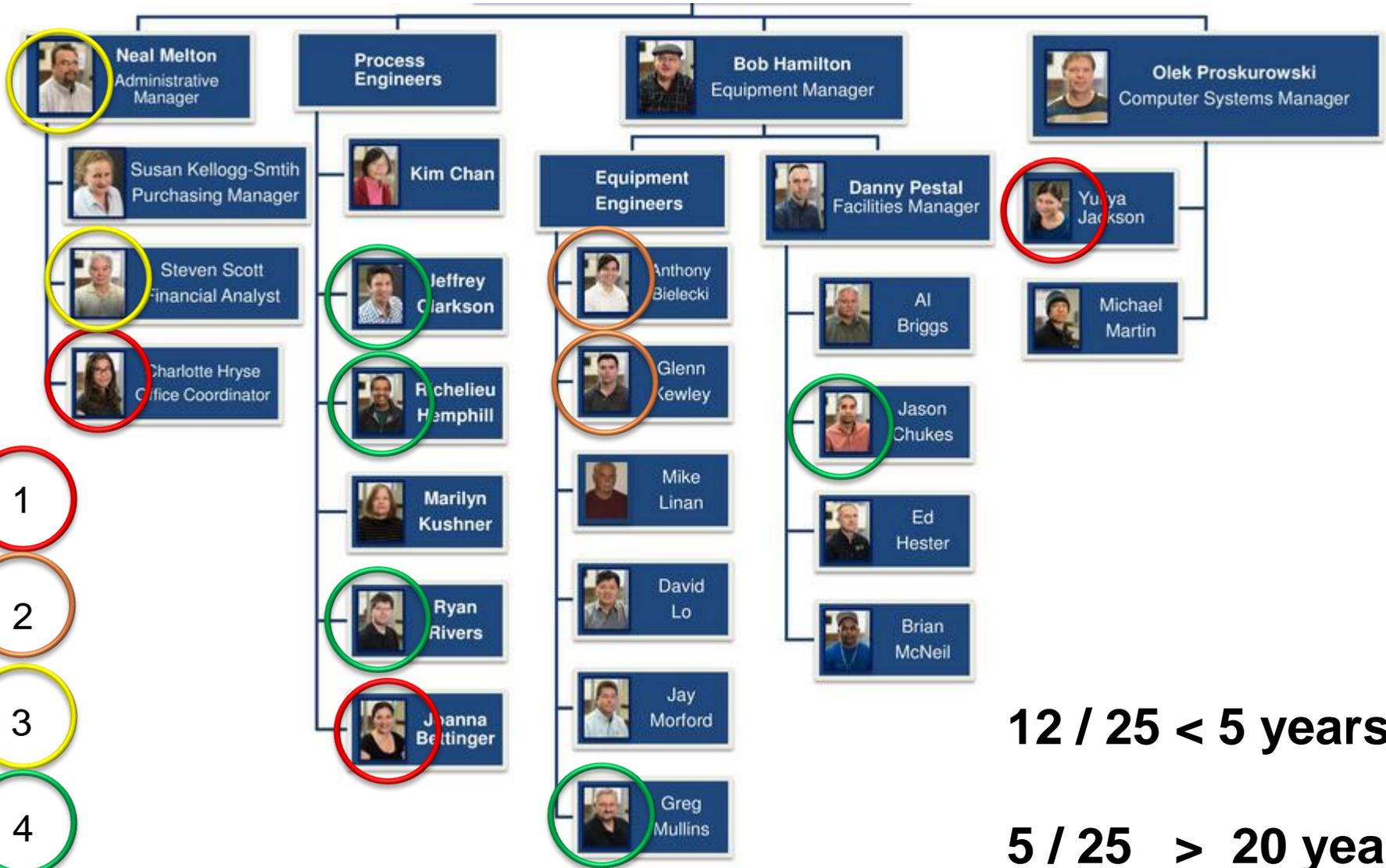
Executive Director



Agenda

- ❖ NanoLab Staff Updates
- ❖ Membership Status and Annual Usage
- ❖ New Equipment / Capabilities
- ❖ FY 15/16 Rates Overview
- ❖ One Time Support from VCR's Office

Staff Organizational Chart



12 / 25 < 5 years

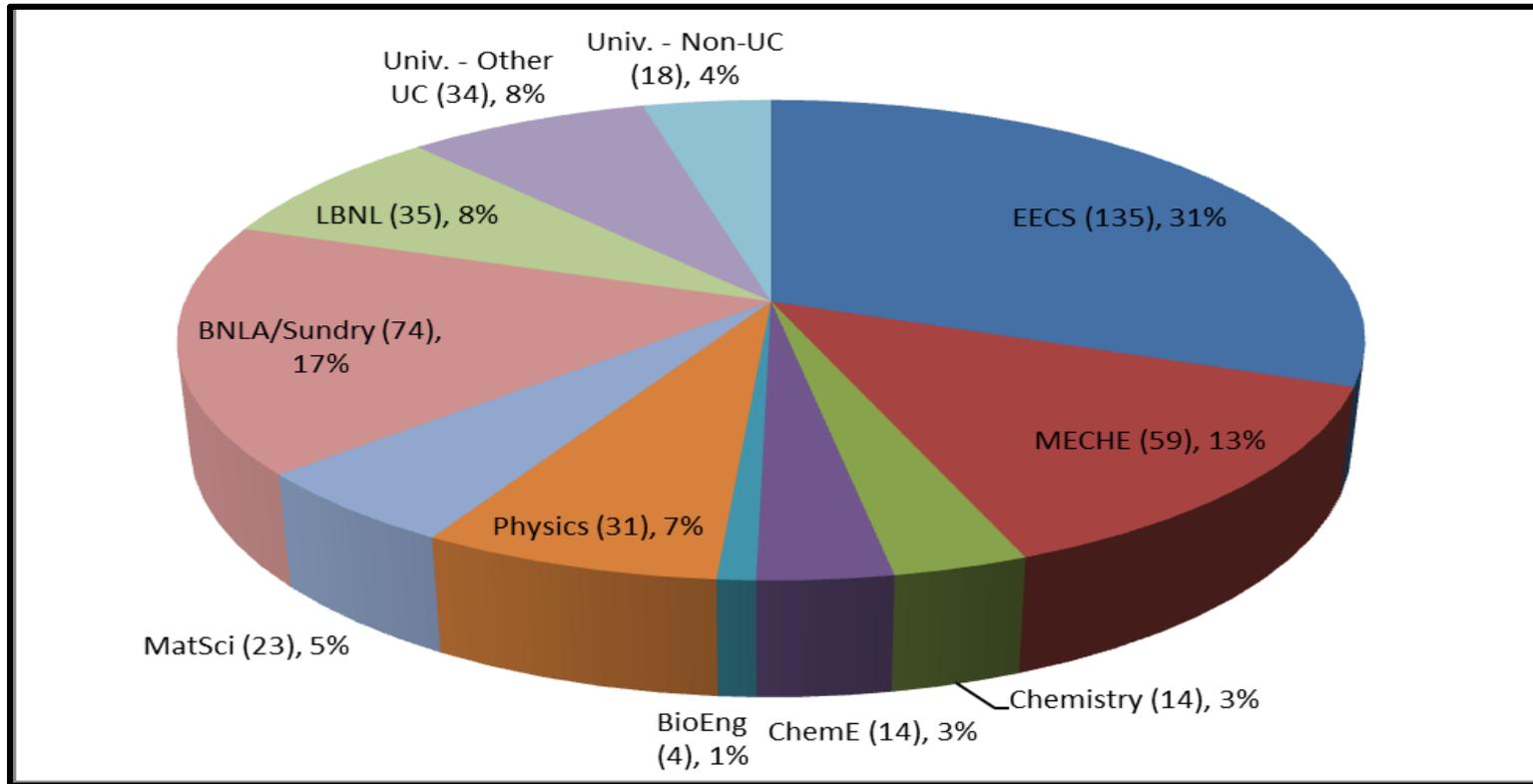
5 / 25 > 20 years

Lab Members by Department

FY 15 Total = 441

Membership is strong and stable.

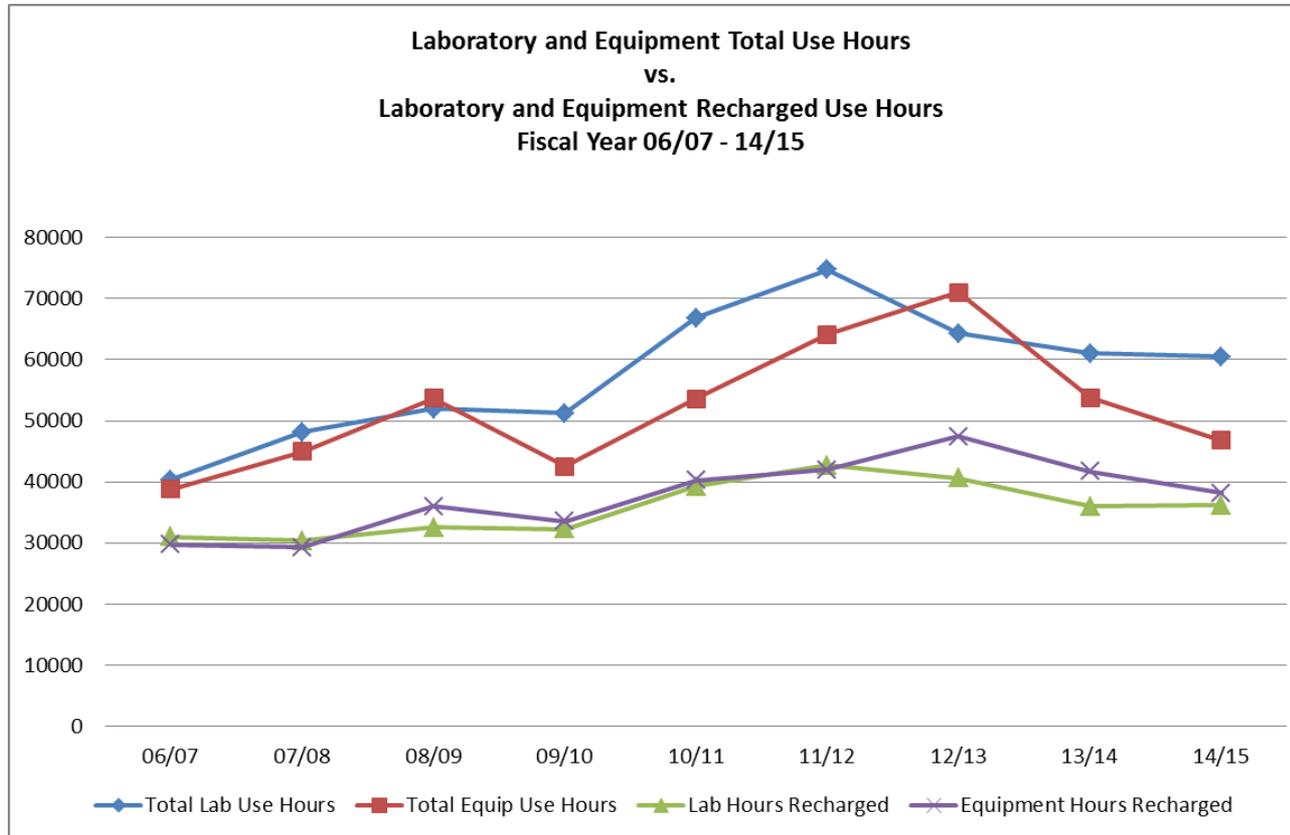
External use is growing



Fiscal Year	2010	2011	2012	2013	2014	2015
Total	469	474	497	471	462	441
UCB	370	353	372	340	326	280
External	99 (21%)	121 (26%)	125 (25%)	131 (28%)	136 (29%)	161 (37%)

The NanoLab is Busy

4.3 – 6.8 people per hour 24/7



Closing the gap between Use Hours and Recharged Hours.

FY13 – Students reminded to log out

FY14 – 1st year with 25% overcap fee

FY15 – overcap fee reduced to 14% (\$6/hour)

New NanoLab Video Available

At the Website and Available for Your Use

A photograph of a sign for the Marvell Nanofabrication Laboratory. The sign is mounted on a light-colored wall and features the text "MARVELL", "NANOFABRICATION", and "LABORATORY" in large, raised, metallic letters. The text is arranged in three lines, with "MARVELL" on the top line, "NANOFABRICATION" in the middle, and "LABORATORY" on the bottom. The lighting is soft, highlighting the three-dimensional nature of the letters.

MARVELL
NANOFABRICATION
LABORATORY

NanoLab Internship Program for High School Young Women

Successful and popular program: 30 alumni since 2001

<https://nanolab.berkeley.edu/public/general/outreach/participants.shtml>

Program had become oversubscribed (>30 applicants last year)

No metric for selection, all were well qualified.

First come first served was primary selection

Program limited to Berkeley High School this year.

Candidates identified by AP Chemistry teacher.

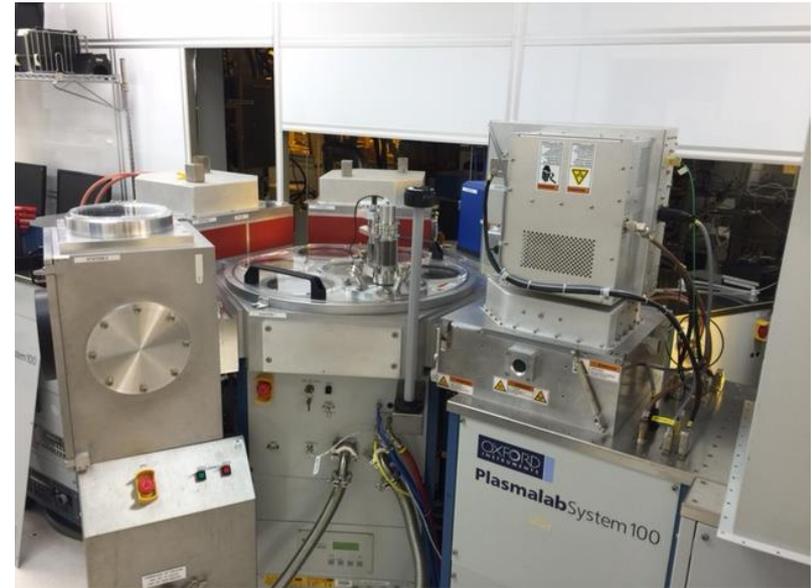
Requested to identify qualified candidates that typically do not apply to intern/science programs.

3 participants interviewed and selected.

Oxford 4 chamber PECVD / PVD cluster

2 PECVD (a-Si, SiO₂, SiN) / 2 PVD (ITO, TBD)

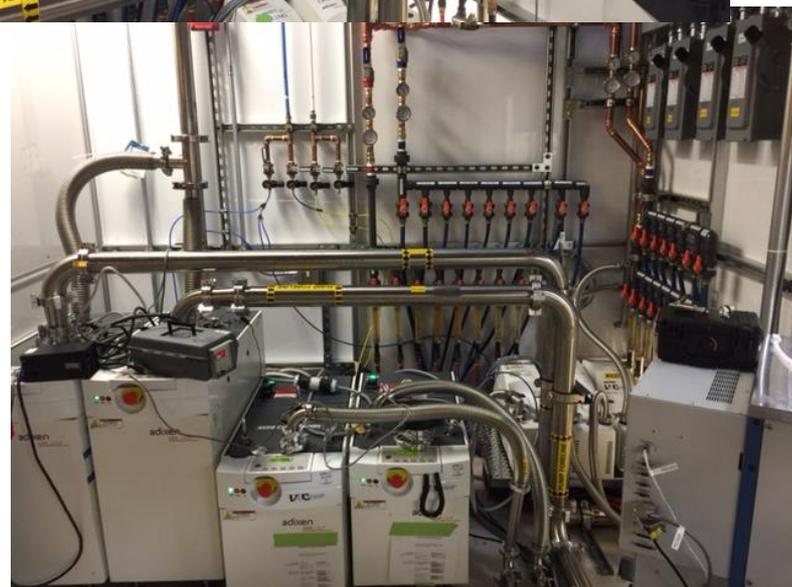
At Hanwha Solar Nov 2014



Sited in NanoLab Nov 2015

Oxford cluster at Berkeley NanoLab

Install January – April 2016



Extensive utility requirements
7 pumps, 4 208V services
4 house gases, 8 specialty gases

PECVD oxide, nitride, SiC released

ASAP Automated Liftoff Tool

Vendor Seeking US University Demo Site



\$284K list price. \$236K “discount”

\$48K NanoLab cost (BNLA fund)

High pressure spray and soak 80°C

2” - 6” substrates

Install complete. Vendor Test May 9

THANK YOU !



Mobile Electrostatic Chuck Technology

Vendor Seeking University Demo Site

THANK YOU !



BEAM SERVICES, INC.

Approved Processes

Lithography

PR Coating on track

PVD/PECVD (Low Temp)

Plasma Etch

Wafer thinning

SEM

Optical inspection

Full emersion/wet etch
(w/approved chemistries)

Annual PI Meeting

Custom electrostatic carrier wafers
~\$1000 each

NanoLab to buy 1st ten and demo
then sell at cost to lab groups

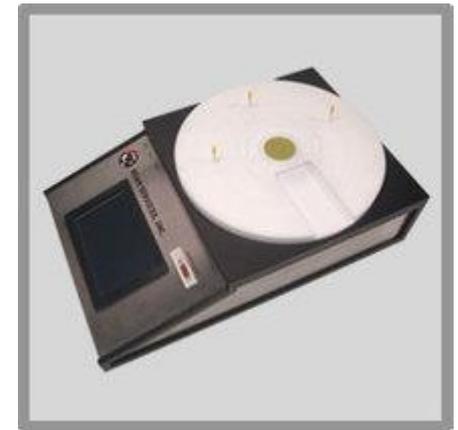
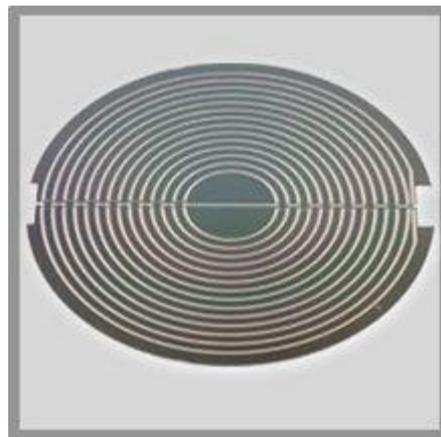


Table top charging system
\$72K List price
Full donation of refurbished unit
Delivery due May 11

May 3, 2016

ebeam evaporator: ebeam1

Fully in house built. CHA “backup”



Egun power supply from retired “dw” evaporator

New 4 pocket hearth system sized
To duplicate heavily subscribed “cha”
(cha cost new \$250K; thank you E3S)

New (PLC controller) and used (pumps
and vacuum chamber)

Parts: ~\$50K

Machine Shop labor for full build and
internal parts fabrication: ~\$45K

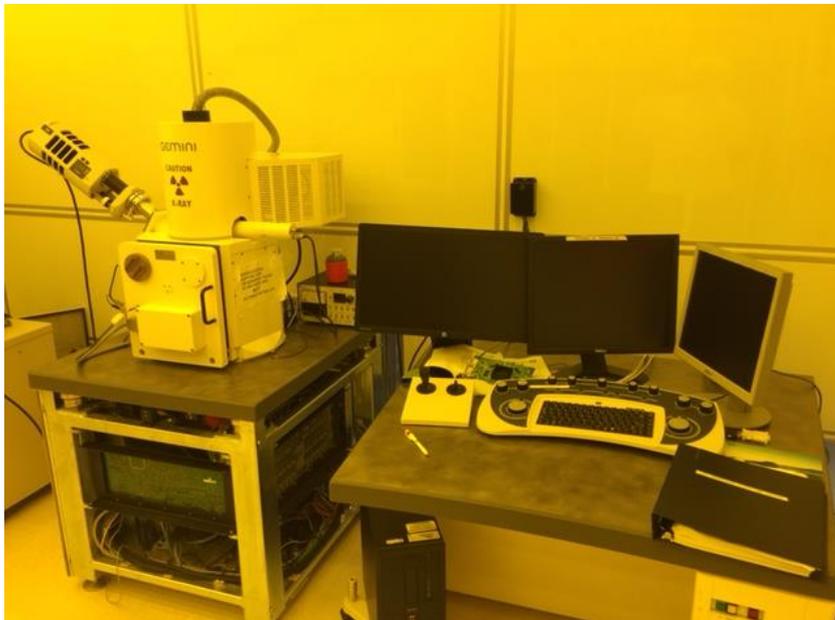
Released April 2016

Zeiss “leo” SEM – NanoLab Work horse

Sep 1997 – Jan 2016 RIP

Self Destruction Failure Analysis:

While awaiting part delivery, simultaneous gate valve failure and ion pump interlock protection failure (vacuum control board) led to constant ionization of room air and extensive corrosion of all internal hardware.



A 2003 vintage used instrument was located and purchased. Release this week (\$50K + \$18.5K install paid from NanoLab Equip Depreciation fund) Model 1540 is dual beam capable

New ebeam writer negotiated

PO Released Dec 2015. Eqpt Review Sep 2016

CABL-UH130

UH110 (110 kV), UH90 (90 kV)

PRICING INFO CONFIDENTIAL
See Lab Management for details

THANK YOU !

CRESTED

- V_{acc}: 130 kV Max (25-130 kV, 5 kV steps)
- Single-Stage Acceleration Electron Gun up to 130 kV
- Micro-Discharge Free Electron Optical Column
- Beam Diameter: < 1.6 nm
- Fine Line: < 7 nm
- Ultra-stable write capability with dual thermal controller
- Pattern Generator: 100MHz



New Thin Film Metrology Capability: FTIR

Compliment to epi Si, Ge and SiGe analysis



Install March 2016

Includes 12.5° reflectance accessory module for “thin” film analysis

Can handle up to 8” wafer

characterize polymer etch residue

Initial characterization of PECVD SiC

Improved control of Si:N ratio in Si₃N₄

FY15/16 and FY 16/17 Academic Recharge Rates

Equipment averaging rather than strict cost of ownership model has been used to address year to year support cost variation vs single fiscal year operations budget requirements

The limitations of this model were addressed by adding new classifications of Equipment when special capabilities with significant support costs were added. e.g., ebeam litho, new SEM

A new model has been developed that uses 3 tiers of equipment averaging.

Tier1: a low level set of equipment that requires some specialized support
Includes: profilometers, wire bonders, parylene, hf vapor.

Sinks, microscopes, manual spinners are still included in the General Lab Rate (Tier0)

Tier2: the former “special equipment” charge category. Most equipment is still here.
Includes: most etch, deposition and lithography.

Tier3: ebeam writer and inspection tools. DUV stepper (ASML300) moved into this higher tier. Simulations were run based on this year’s billing; ~5% max changes observed. Report any significant impact to Lab Management.

FY15/16 and FY 16/17 Academic Recharge Rates

	Academic Rates	
	FY 2015/16	FY 2016/17
Access Fee	\$91.00	\$91.20
General Laboratory Rate	\$45.00	\$45.00
General Lab Rate Max	\$1,350.00	\$1400.00
Special Equip Rates	\$43.20	Tier 1: \$21.00 Tier 2: \$44.40
Special Equipment Rate Max	\$1,560 <i>Rate over cap: \$6.05/hour</i>	Tier 1: \$200.00 Tier 2: \$1,400.00 <i>Rate over Tier 2 cap: \$6.15/hour</i>
E-beam Lithography	\$94.80 <i>(\$0.00 between \$2,400 - \$4,800, \$94.80/hour after \$4800)</i>	Tier 3: \$63.60 <i>Tier 3 cap: \$1,500.00</i>
High Performance SEM	\$60.00 <i>(\$0.00 between \$300-\$600, \$58.80/hour after \$600)</i>	<i>Rate over Tier 3 cap: \$19.60/hour</i>
Staff Services	\$79.20	\$84.00

FY15/16 and FY 16/17 BNLA Recharge Rates

	BNLA Rates	
	FY 2015/16	FY 2016/17
Access Fee	\$114.80	\$116.00
General Laboratory Rate	\$51.60	\$49.20
General Lab Rate Max	\$2,400.00	\$2,450.00
Special Equipment Rate	\$49.20	Tier 1: \$21.00 Tier 2: \$51.00
Special Equip Rate Max	n/a	n/a
E-beam Lithography	\$121.20	Tier 3: \$80.40
High Performance SEM	\$78.60	
Staff Services	\$79.20	\$84.00

BNLA Membership Fees

Yearly BNLA Fees			
FY 15/16		FY 16/17	
Lab Members Per Company	Annual Rates	Lab Members Per Company	Annual Rates
1	\$17,500	1	\$18,500
2	\$27,500	2	\$28,500
3 - 4	\$37,500	3	\$38,500
5 - 6	\$55,000	4	\$42,500
		5	\$55,000
General Cap	\$2400	General Cap	\$2450
Equip Cap	None	Equip Cap	None

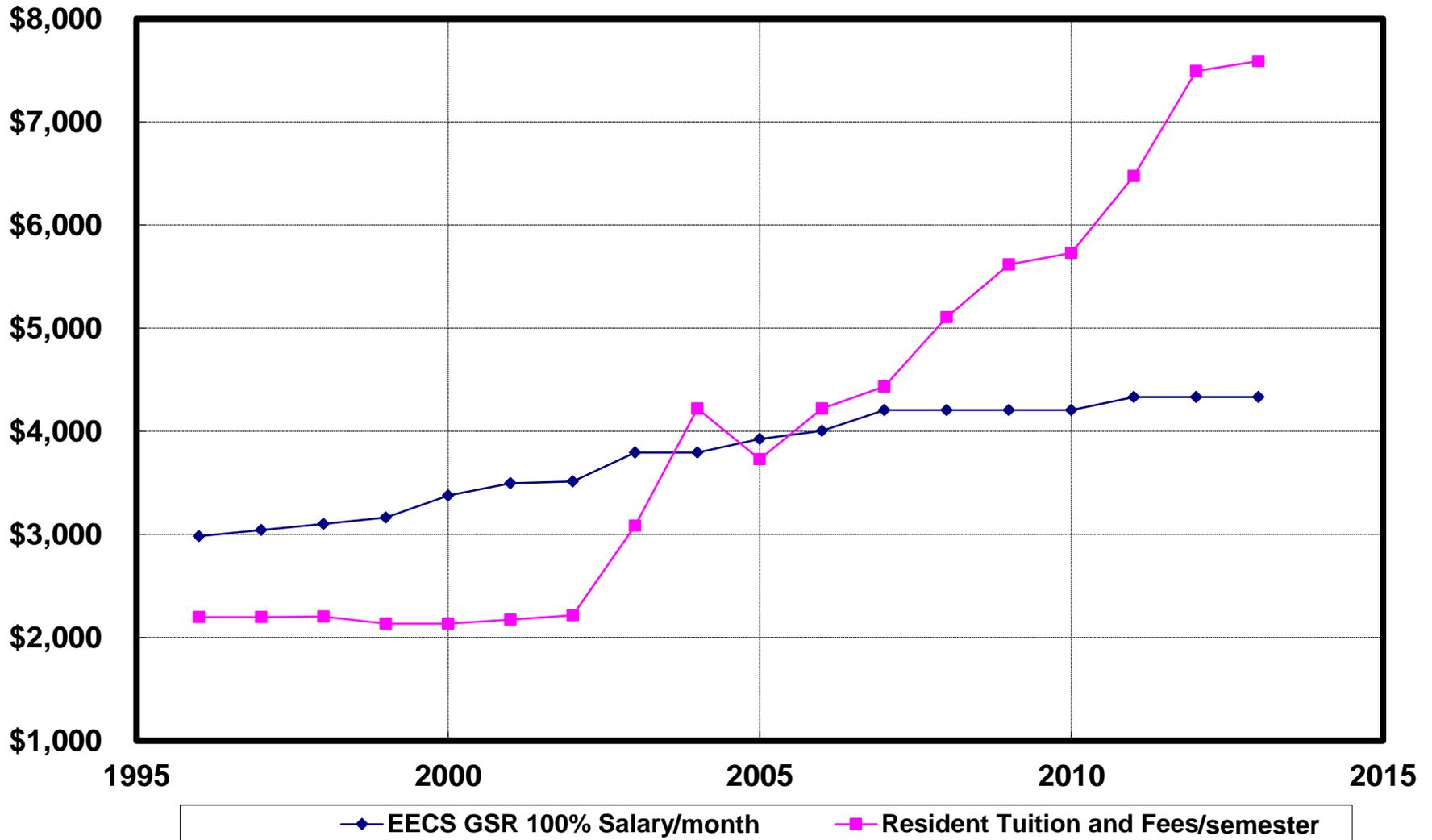
Staff Benefit and Campus Overhead Rates

Benefit Rate Increase 18% in past 5 years
> 20% (almost double) expected over 7 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	46	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



Fulfilled VCR Investment in the NanoLab

- CITRIS Director Prof Costas Spanos negotiated one time VCR investment in the NanoLab. Thank you Costas!
 - \$250K delivered in FY 15, used for new Oxford tool
 - \$250K add in FY16 if NanoLab secures match.
- FY15 funds used to purchase 4 chamber PECVD/PVD
 - ❖ Virtually new 2011 tool marketed for \$400K
 - ❖ Brokers offered \$200K
 - ❖ NanoLab offered \$300K + Gift Acknowledgement
 - ❖ Tool appraised by 3rd party at UC expense for \$950K!
 - ❖ VCR match requirement met!
- FY16 \$250K
 - \$100K to crestec Ebeam downpayment
 - \$100K to wafer bonder

Summary

- Smooth staff transitions continue

- Academic Rate Lab and Equipment Increases <2%
 - ❖ Over cap rate maintained at only \$6/hr
 - ❖ New 3 Tier equipment rate in place for next fiscal year
 - ❖ Report to Lab Management if this has unexpected impact on your lab recharge expenses

- NanoLab Staff fixed costs are steadily increasing
- NanoLab recharge rate increases are << than university increases
- NanoLab rate increases have focused upon external non-academic
 - ❖ BNLA Rate Increases 4 – 10%

- NanoLab continues to expand capabilities

- VCR investment in NanoLab supporting PECVD, ebeam, bonding



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

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



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

UC Berkeley EECS Professor,
William G. Oldham



Thank you