



**Marvell
Nanofabrication
Laboratory**

2015 Principal Investigators Meeting

Professor Ming C. Wu

Faculty Director

Dr. Bill Flounders

Executive Director



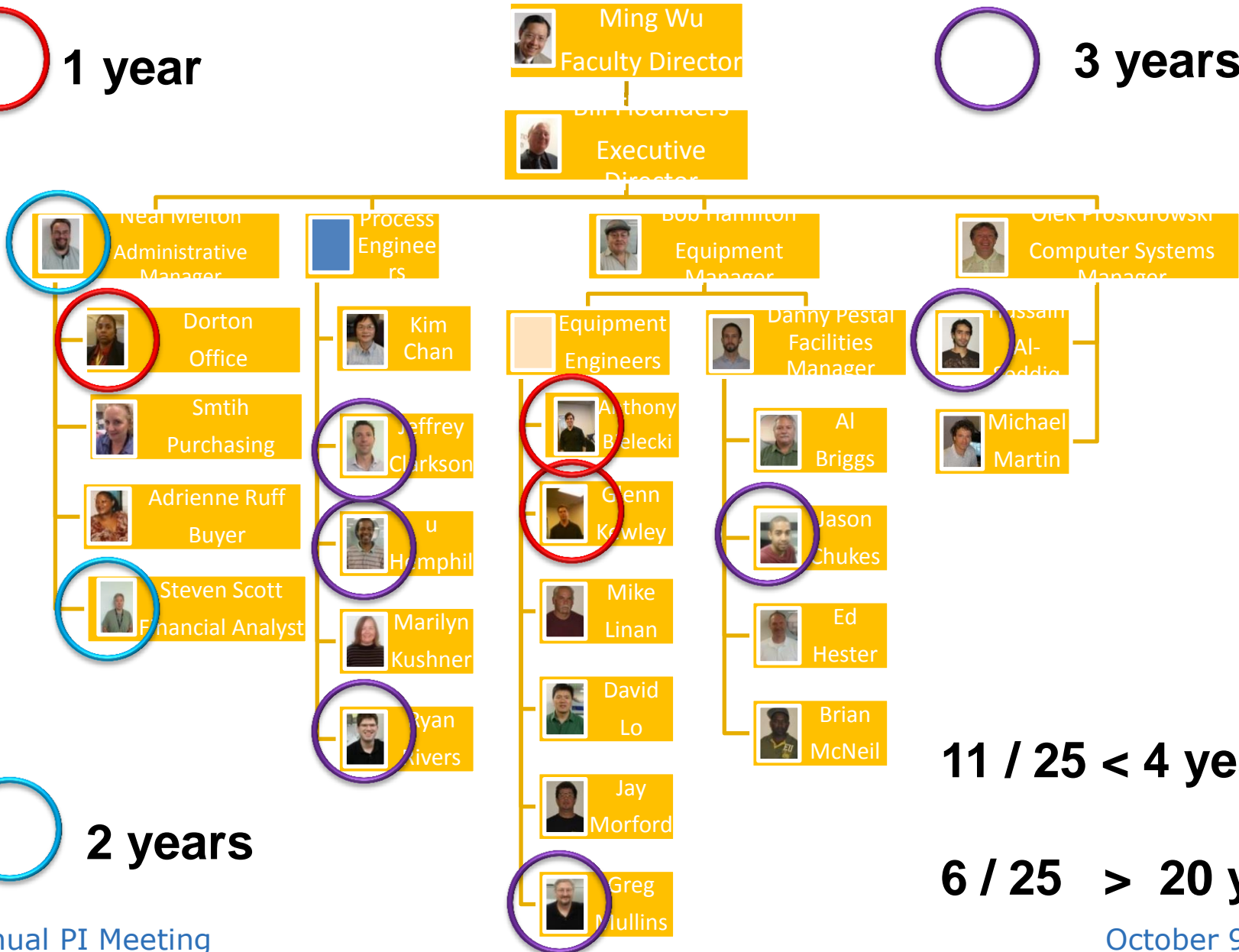
Agenda

- ❖ 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

 1 year

 3 years



 2 years

11 / 25 < 4 years

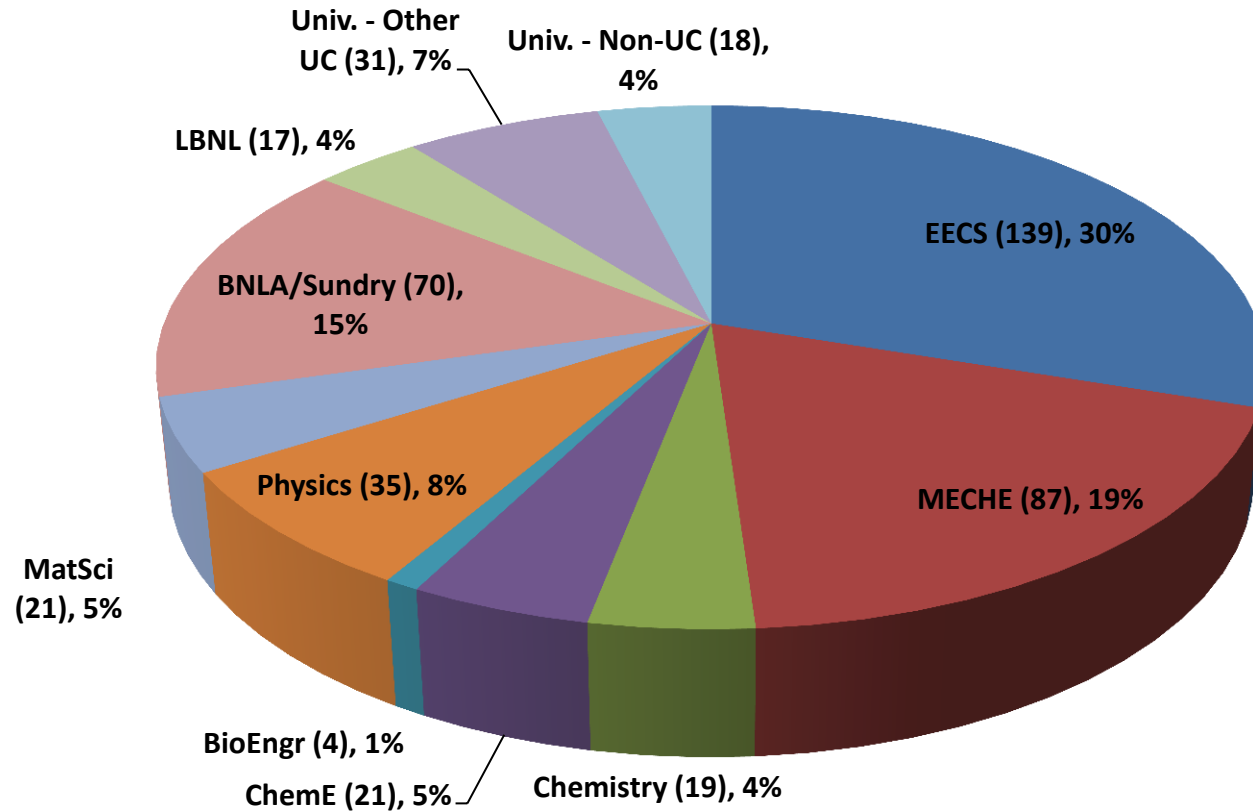
6 / 25 > 20 years

Lab Members by Department

FY 14 Total = 462

Membership is strong and stable.

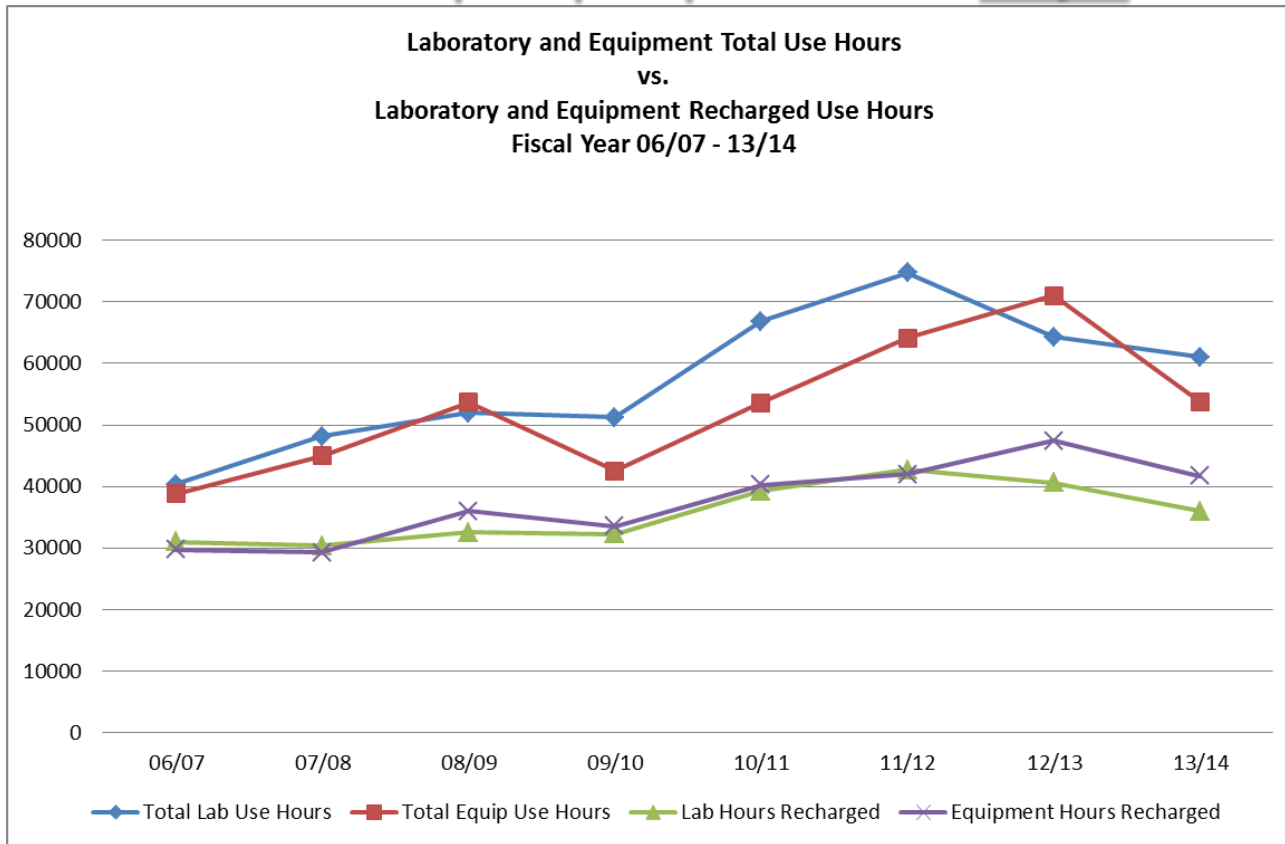
External use is growing



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

The NanoLab is Busy

4.3 – 7 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



<https://www.youtube.com/embed/EwfChuacUCg>

NanoLab High School Girls Intern Program

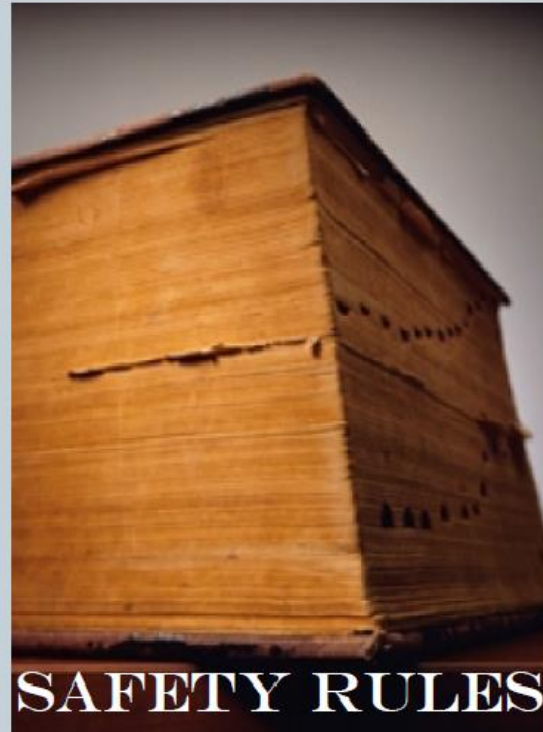
Going Strong: 25 alumni, 4 new graduates this summer

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

The Essentials



BUNNY SUIT

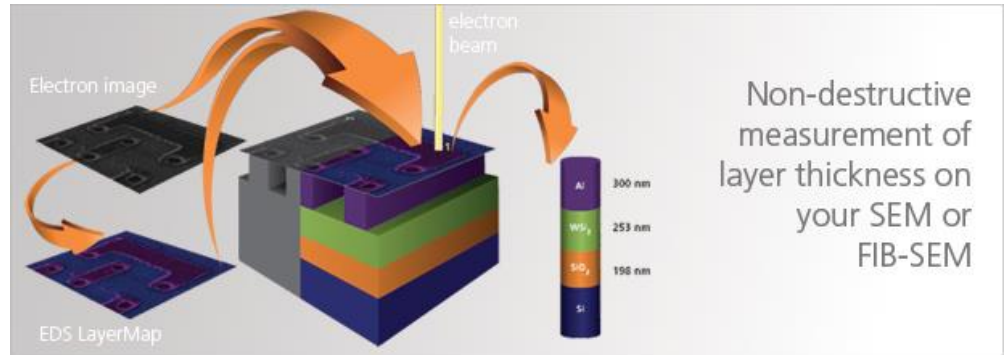
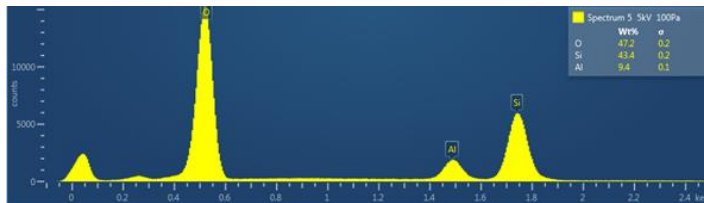


SAFETY RULES

New Tools / Capabilities This Year

- Welcome “edx” : energy dispersive xray spectroscopy.
 - ❖ Detector addition to leo SEM
 - ❖ First chemical compositional analysis capability in the NanoLab
- Welcome new “xetch”: xenon difluoride etcher
 - ❖ 2007 Commercial version of homebuilt tool from 1996
 - ❖ Same etch but improved uniformity and reliability
- Welcome oxford3,4,5,6: four chamber PECVD/PVD cluster tool
 - ❖ 2 chambers Dual frequency PECVD: a-Si, SiO₂, SiN
 - ❖ 2 chambers reactive sputter dep: ITO and “TBD”
- Well Hello “amat-epi”: epi Si and epi Ge deposition
 - ❖ 2009 delivery, Lab move/startup, 2013 site and connect
 - ❖ 2014 add abatement, 2015 first films

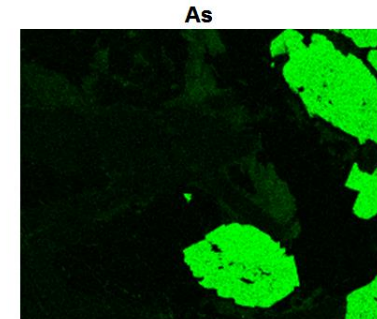
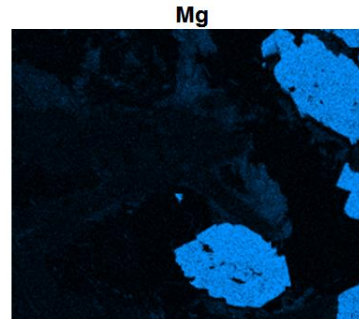
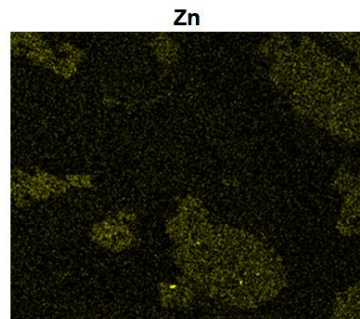
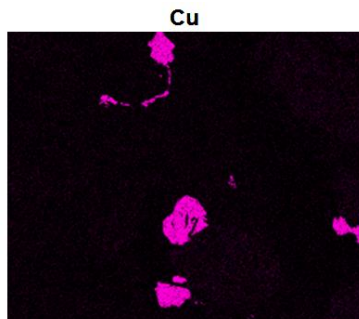
New Capability: EDX Added to Leo SEM



Oxford Instruments Aztec X-MaxN 50

- 125 eV resolution
- Detection down to Be (Z = 4)

LayerProbe – A thin film analysis technique to perform non-destructive measurements of film thickness and composition below a sample's surface.



Elemental Mapping - Determination of phase and element distribution within a sample.

Updated Capability: XeF2 Etch System



- Beta demo tool built by Mshop 1996
- Kyle Leboutz goes on to found Xactix
- 19 years service
- Home developed lab view control
- Uniformity decrease – shower head and chamber rebuild required



- The Xactix X3! Built 2007. Hardly used
- Supportable software
- Fresh chamber and shower head
- New pump. Integrated camera
- Rapid pulse mode.
- Little technical change but with improved uniformity and reliability

New 4 Chamber Deposition Cluster

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



Install underway. Facilities completed by November 2
Release planned for January 2016

AMAT epi-Si/Ge arrival



AMAT epi-Si/Ge Installed

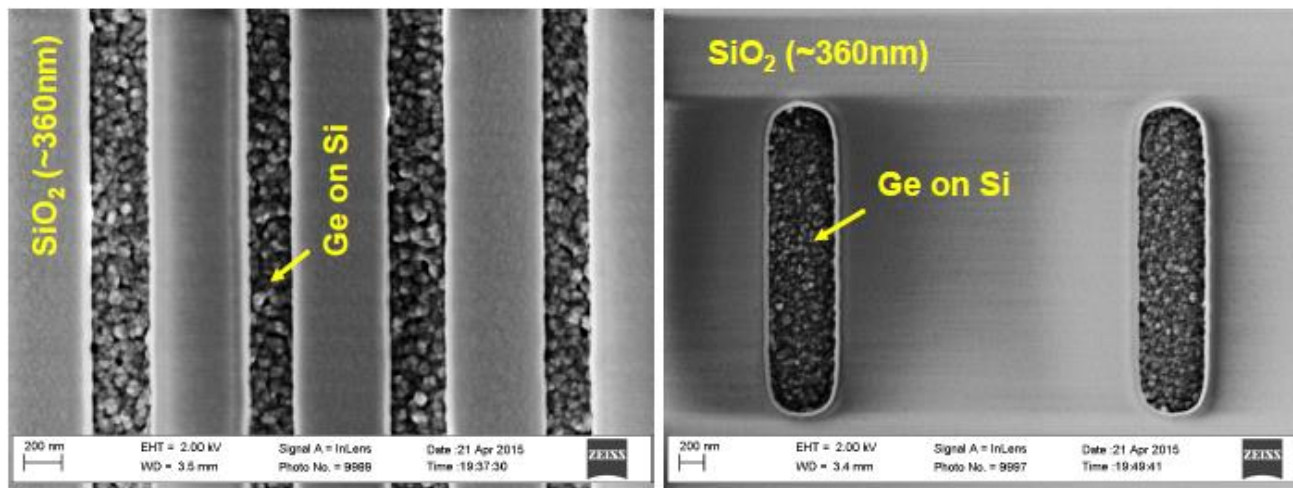


AMAT epi-Si/Ge

Selective epi-Ge Deposition: Prof King Liu, Dr. K Kato

Ge selective deposition by AMAT epi.

- Oxide deposition, Annealing, and patterning
- HCl cleaning *No HF dip*
- H₂ annealing (1190°C, 300s)
- Ge deposition (400°C, GeH₄: 30sccm, 423s)



- Ellipsometer / spectro-reflectometer analysis of SiO₂/Si area
 - Perfect fit of measured and model (SiO₂/Si) spectra → No Ge on top
 - SiO₂ thickness reduction by H₂ annealing: 1.7 nm
- Good deposition selectively of Ge

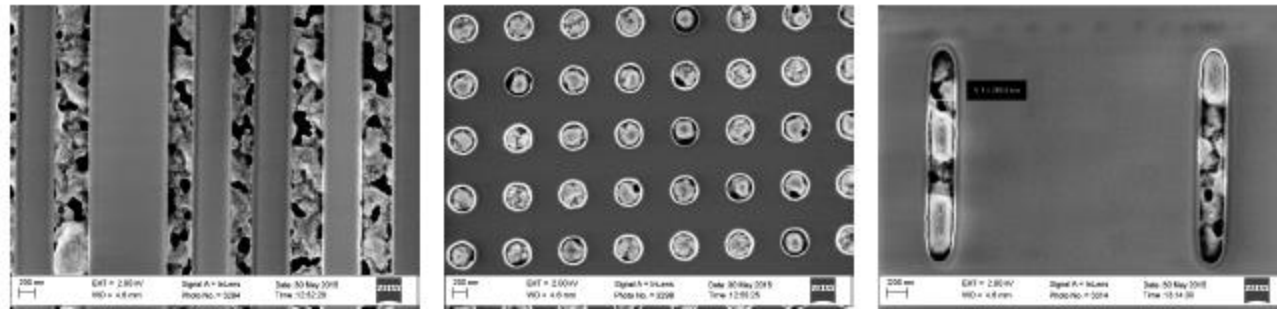
AMAT epi-Si/Ge

Selective epi-Ge Deposition: Prof King Liu, Dr. K Kato

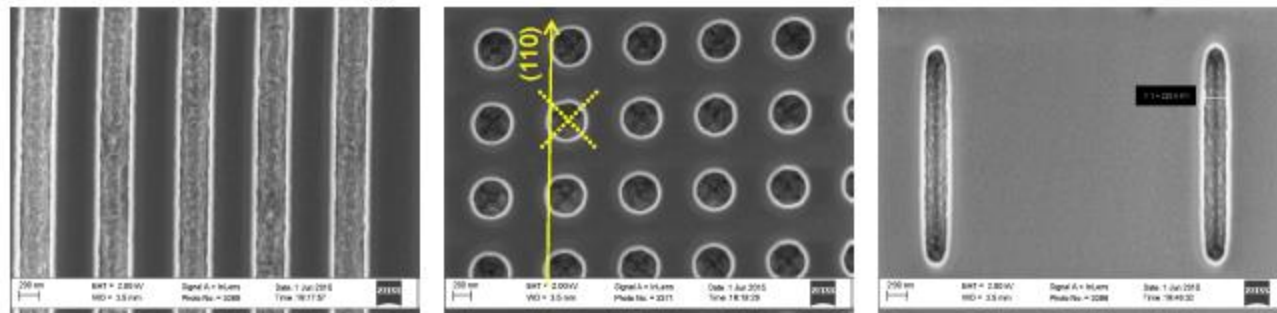
Ge selective epitaxy after sacrifice oxidation

- LTO deposition (~360nm), Anneal, and Patterning by centura-mxp
- Thermal oxidation (1000°C, 13min, SiO₂: 19.4nm ... 9.0nm Si consumed)
- HCl and HF cleaning (H₂O:HF = 50:1, 5min ... SiO₂ etched within 3.5min)
- Epi processes (H₂ bake @1000 or 1190°C → Epi @400°C → Anneal @825°C)

H₂ bake: 1190°C, 5min ☺ Very clear facet partially
☹ Non-uniform and voids



H₂ bake: 1000°C, 5min ☺ Relatively uniform, Feeble “X” mark in narrow hole and trench edge
☹ Rough surface



FY15/16 Academic Recharge Rates

Category	FY 2013/14	FY 2014/15	FY 2015/16	% change
Access Fee	\$91.50	\$92.60	\$91.00	(1.7%)
General Laboratory Rate	\$43.20	\$44.40	\$45.00	1.4%
General Lab Rate Max	\$1,300.00	\$1,332.00	\$1350.00	1.4%
Special Equipment Rate	\$40.80	\$42.00	\$43.20	2.9%
Special Equip Rate Max	\$1,500.00	\$1,540.00	\$1,560.00	1.3%
Special Equip Volume Rate	\$10.20	\$6.00	\$6.05	1%
E-beam Lithography	\$111.00	\$110.40	\$94.80	(14.1%)
High Performance SEM	\$60.00	\$60.00	\$58.00	(3.3%)
Staff Services	\$75.00	\$78.60	\$79.20	1%

FY15/16 BNLA Recharge Rates

Category	FY 2013/14	FY 2014/15	FY 2015/16	% change
Access Fee	\$91.50	\$108.65	\$114.80	5.7%
General Laboratory Rate	\$43.20	\$47.40	\$51.60	8.9%
General Lab Rate Max	\$2,200.00	\$2,300.00	\$2,400.00	4.3%
Special Equipment Rate	\$40.80	\$50.40	\$49.20	(2.4%)
E-beam Lithography	\$111.00	\$124.20	\$121.20	(2.4%)
High Performance SEM	\$60.00	\$72.00	\$78.60	9.2%
Staff Services	\$75.00	\$78.60	\$79.20	1%

FY15/16 BNLA Membership Fees

Lab Members/Company	Yearly BNLA Fee		
	Previous (since 2001)	Effective 7/1/13	Effective 7/1/15
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

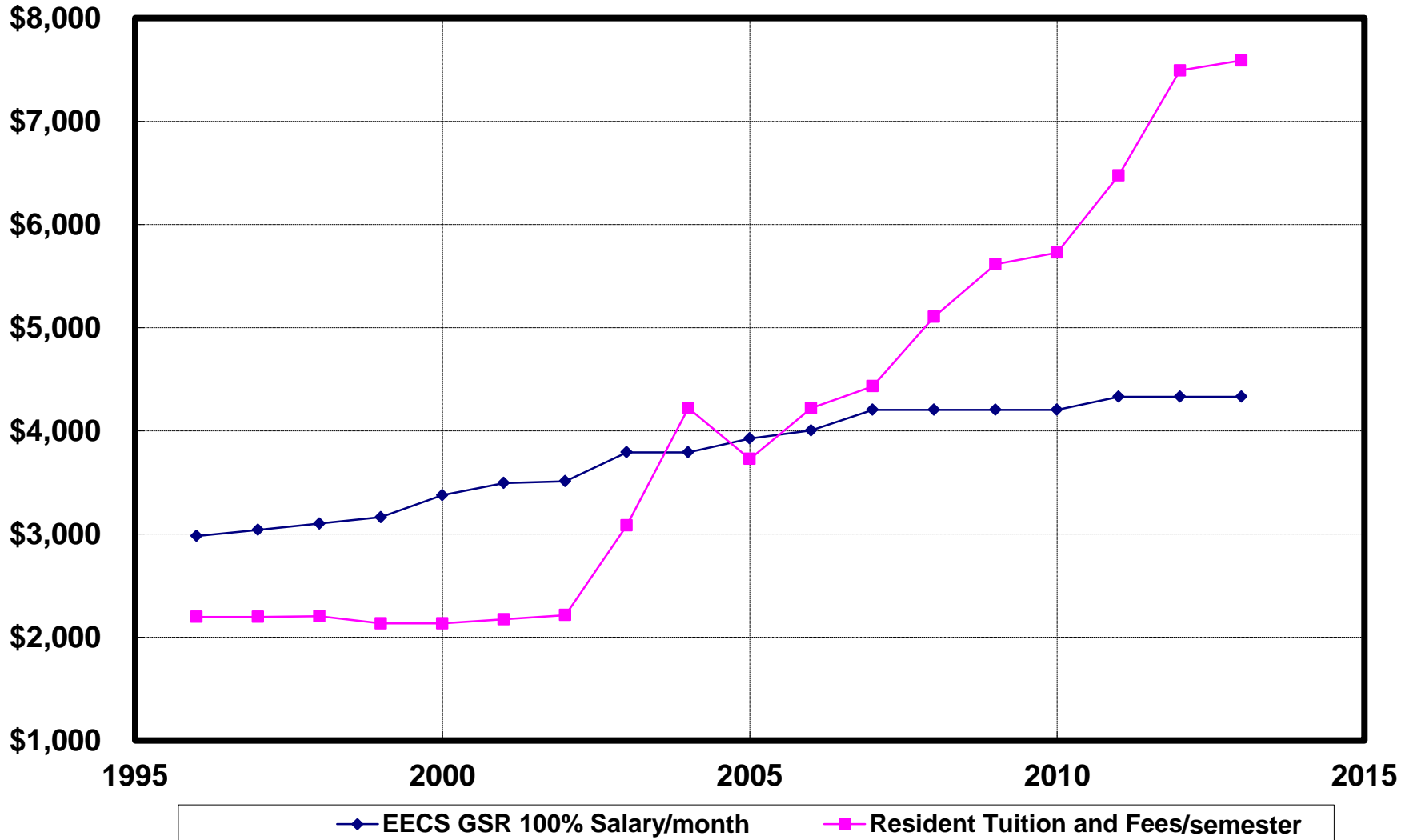
Benefit Rate Increase 13.5% in past 3 years

> 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



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
- \$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!

Summary

- Smooth staff transitions continue
- Academic Rate Lab and Equipment Increases <2%
 - ❖ Over cap rate maintained at 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 – 10%
- NanoLab continues to expand capabilities
- NanoLab received first ever VCR investment

Six years ago...

Gray Davis Handed Us an Empty Lab



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.**



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

UC Berkeley EECS Professor,
William G. Oldham



Thank you