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
Lab Members by Department

Membership is strong and stable. External use is growing

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tbody>
<tr>
<td>Total</td>
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<td>474</td>
<td>497</td>
<td>471</td>
<td>462</td>
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<td>UCB</td>
<td>370</td>
<td>353</td>
<td>372</td>
<td>340</td>
<td>326</td>
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<td>External</td>
<td>99</td>
<td>121</td>
<td>125</td>
<td>131</td>
<td>136</td>
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<tr>
<td>External %</td>
<td>21</td>
<td>26</td>
<td>25</td>
<td>28</td>
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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

[Image: Bunny Suit and 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 Eetch System

- Beta demo tool built by Mshop 1996
- Kyle Lebouitz 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 \textit{No HF dip}
- H$_2$ annealing (1190°C, 300s)
- Ge deposition (400°C, GeH$_4$: 30sccm, 423s)

- Ellipsometer / spectro-reflectometer analysis of SiO$_2$/Si area
  - Perfect fit of measured and model (SiO$_2$/Si) spectra → No Ge on top
  - SiO$_2$ thickness reduction by H$_2$ 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°C 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
<table>
<thead>
<tr>
<th>Category</th>
<th>FY 2013/14</th>
<th>FY 2014/15</th>
<th>FY 2015/16</th>
<th>% change</th>
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<tr>
<td>Access Fee</td>
<td>$91.50</td>
<td>$92.60</td>
<td>$91.00</td>
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<td>General Laboratory Rate</td>
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<td>$44.40</td>
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<td>General Lab Rate Max</td>
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<td>$1,332.00</td>
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<tr>
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<td>$78.60</td>
<td>$79.20</td>
<td>1%</td>
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<tr>
<td>Category</td>
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<td>FY 2014/15</td>
<td>FY 2015/16</td>
<td>% change</td>
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<td>$108.65</td>
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<td>E-beam Lithography</td>
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## FY15/16 BNLA Membership Fees

<table>
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<tr>
<th>Lab Members/Company</th>
<th>Previous (since 2001)</th>
<th>Effective 7/1/13</th>
<th>Effective 7/1/15</th>
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<td>1</td>
<td>$15,000</td>
<td>$17,500</td>
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<td>2</td>
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<td>5 - 6</td>
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<td>General Cap</td>
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<tr>
<td>Equip Cap</td>
<td>None</td>
<td>None</td>
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Staff Benefit and Campus Overhead Rates

Benefit Rate Increase 13.5% in past 3 years
> 20% (almost double) expected over 6 years

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<td>Academic Benefit %</td>
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<td>36.8</td>
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<td>42.1</td>
<td>42.6</td>
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<tr>
<td>Staff Benefit %</td>
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<td>33</td>
<td>38</td>
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<td>47.6</td>
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<td>Campus Overhead %</td>
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<td>55.5</td>
<td>55.5</td>
<td>56.5</td>
<td>56.5</td>
<td>57</td>
<td>TBD</td>
<td>TBD</td>
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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

Marvell Nanofabrication Laboratory UC Berkeley

Aircraft Carrier Style
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