What Goes on Behind Open Doors: 
Fabrication Capabilities at 
UC Berkeley Microfabrication Laboratory 

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*Operations Manager*

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Monthly Meeting Plasma Etch Users Group 
of Northern California Chapter American Vacuum Society 
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Outline

• Berkeley Microlab Overview
• Summary of Capabilities
• Access Programs and Recharge Rates
• Select Plasma Etch Capabilities
• Conclusions
The First University IC Lab

...was built in 1962 at UC Berkeley
The Microlab

...expanded around the IC lab and opened in 1982

A shared facility:

The Microlab has supported research across 7 departments, multiple campuses, and national labs for 20 yrs
Microlab research covers a broad range of areas

- **Si-based IC devices and technology**
  - new materials and processes, nanoscale devices (*e.g.* the “FinFET”)

- **Micro-electromechanical systems (MEMS)**
  - sensors and actuators; microphotonics; microfluidics, bioMEMS, *etc.*

- **Optoelectronic devices**
  - semiconductor lasers (VCSELs)

- **Lithography**
  - resist modeling; EUV lithography; maskless lithography

- **Semiconductor manufacturing**
  - process monitoring; yield modeling; metrology

- **Superconductive devices**
  - integrated Nb/Al$_2$O$_3$/Nb Josephson junction process
# A sampling of research faculty

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Principal Investigators</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC Devices &amp; Technology</td>
<td>Bokor, Cheung, Hu, King, Subramanian</td>
</tr>
<tr>
<td>MEMS</td>
<td>Boser, Fearing, Howe, *Lee, *Liepmann, ^Lin, @Maboudian, ^Majumdar, Muller, ^Pisano, Pister, Sanders, ^Tien, White</td>
</tr>
<tr>
<td>Optoelectronics</td>
<td>Chang-Hasnain, Lau, %Sands, Smith, Weber</td>
</tr>
<tr>
<td>Lithography</td>
<td>Attwood, @Frechet, Neureuther, Oldham</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Hodges, Spanos</td>
</tr>
<tr>
<td>Superconductive Devices</td>
<td>#Clark, van Duzer</td>
</tr>
</tbody>
</table>

*Bioengineering*  @Chemistry/Chem. Engr.  % Mat. Sci. & Engr.  ^Mech. Engr.  #Physics
A sampling of Microlab educational programs

- Support of laboratory courses
  - EE143: Microfabrication Technology
  - C133 (ChE/ME/EECS): Microfabrication Equipment Lab

- Graduate student training and research; seminars
  - EE298-12: Solid-State Technology and Devices
  - EE298-24: Berkeley Sensor and Actuator Center Seminar

- Undergraduate student research apprenticeships

- Berkeley summer youth works (high school program)

- Summer internship program for high school students

- Visiting professor & minority researcher programs
The Microlab Today

... is used by ~350 researchers (>70 faculty) from UCB, UCD, UCSB, UCSD, LBNL, LLNL, SNL

percentage of users from each group:
Overview UC Berkeley Microlab Tools

Thermal process (oxidation, diffusion, anneal)
- 12 atmospheric furnaces, 3 RTP systems
- solid source boron doping
- SiC tube available for up to 1200 °C

CVD
- 8 LPCVD tubes poly-Si, poly-Ge, poly SiGe, Si₃N₄, SiO₂
- 3 PP PECVD
- recent install Applied Materials P5000 TEOS,
- custom RTCVD

Litho
- ASML 6” 248nm, 5:1 stepper,
- Karl Suss up to 6” contact align/bond alignner, backside capable
- 2 GCA 10:1 4” steppers, (g-line, i-line)
- Quintel up to 6” contact align, backside capable
- 6” and 4” SVG coat and develop tracks
Overview UC Berkeley Microlab Tools

Etch
- Lam oxide, poly, nitride, aluminum etchers
- STS DRIE
- Technics parallel plate nitride etcher
- 3 O2 asher/etcher
- XeF2 reactor for silicon etch
- Wet etch: Al, poly-Si, KOH, TMAH, H₃PO₄, HF, CPD

PVD
- Novellus 6” 5 chamber sputter deposition (Al, AlN, Ti, TiN, Mb)
- CPA 4 target sputter dep (Al/2% Si, Ti, W, Ni)
- 3 thermal, 2 ebeam evap
- 4 additional multi-target sputter dep systems

Planarize and Package
- Strasbaugh 6”/4” CMP, 6” Disco dicing saw, Au / Al wore bond

Limited plating capability, no ion implantation
Three Separate Access Programs
MEMS Exchange, BMLA, BSAC

• MEMS Exchange
  • Full details can be found at: http://www.mems-exchange.org/
  • Supported by DARPA, Defense Advanced Research Projects Agency
  • Hosted by CNRI, the Corporation for National Research Initiatives

  • Coordinated network of distributed fabrication centers
    • Berkeley, Stanford, Cornell, Michigan, Illinois, Case Western, Louisiana
    + ~15 industrial labs

  • MEMS exchange is a fee for service program;
    it does not enable laboratory access

  • Approximately 75% of UCB tools available through MEMS Exchange
Access Programs

• **BMLA Berkeley Microlab Affiliates**
  - Full details at: [http://argon.eecs.berkeley.edu:8080/text/bmla.html](http://argon.eecs.berkeley.edu:8080/text/bmla.html)
  - Cooperative Agreement between Member companies and U.C.; for educational, training, research or other experimental purposes,
  - BMLA membership provides complete laboratory access; BMLA is not a fee for service program
  - 100% of UCB tools available through BMLA
    specialty tool modifications and gases considered
  - Requirements:
    • brief summary of proposed processing reviewed with Operations Manager and Faculty Director
    • training in safety, facilities procedures, and equipment operation
BMLA Membership Fee
Effective 7/1/02 – 6/30/03

<table>
<thead>
<tr>
<th>Number of employees per member company</th>
<th>Annual BMLA membership fee</th>
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<tr>
<td>1</td>
<td>$15K</td>
</tr>
<tr>
<td>2</td>
<td>$25K</td>
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<tr>
<td>3-4</td>
<td>$35K</td>
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<td>5-6</td>
<td>$50K</td>
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maximum of 6 employees from any member company
### BMLA Recharge Rates

**Effective 7/1/02 – 6/30/03**

<table>
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<th>Service</th>
<th>Rate</th>
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<tr>
<td>Access Fee</td>
<td>$83.70/month</td>
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<tr>
<td>Lab Fee</td>
<td>$32.40/hour</td>
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<tr>
<td>Special Equipment</td>
<td>$30.00/hour</td>
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<td>Exceptional Equipment</td>
<td>$34.00/hour</td>
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<tr>
<td>Staff Services</td>
<td>$66.00/hour</td>
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</table>

University researcher standard rates

- furnaces, steppers
- pattern generator
- Lam etchers
- ASML stepper
- AMAT P5000
- Novellus m2i

**plus 50% overhead fee**
BMLA List of Companies
as of July, 2002

Adriatic Research Institute
Advanced Integrated Photonics, Inc.
Alien Technology Corp.
Emitronix, Inc.
The Fox Group, Inc.
General Nanotechnology
Integrated Nanosystems, Inc.
Intel Corporation
Jet Propulsion Laboratory
Luxnet Corporation
MEMS PI

MicroAssembly Technologies
MicroGen Systems, Inc.
Molecular Reflections
Nanochip, Inc.
Nanomix, Inc.
NewPeregrine, Inc.
Network Photonics Inc.
Onix Microsystems, Inc.
Photon Imaging, Inc.
Progressant Technologies, Inc.
Robert Bosch Corporation
Access Programs

• Berkeley Sensor and Actuator Center
  • Full details can be found at: http://www-bsac.eecs.berkeley.edu/
  • An NSF/Industry/University Cooperative Research Center
  • Annual membership fee $50K sometimes offset by equipment donation
  • Provides direct access to research projects and faculty through closed meetings and limited distribution research reports

  • BSAC Membership does not provide laboratory access
  • BSAC members are supported by BSAC engineers who have full laboratory access
  • 100% of UCB tools are available to BSAC engineers
  • BSAC members may also become BMLA members

  • BSAC members may also sponsor specific research projects with UCB faculty. This provides full access to laboratory through sponsorship of graduate student and post-doctoral researchers
# Select Plasma Etch Capabilities

<table>
<thead>
<tr>
<th>Platform</th>
<th>Lam1</th>
<th>Lam2</th>
<th>Lam3</th>
<th>Lam3</th>
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<tr>
<td></td>
<td>480</td>
<td>590</td>
<td>690</td>
<td>PLL</td>
<td>4400</td>
<td>9400</td>
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<td>4&quot;/6&quot;</td>
<td>4&quot;/6&quot;</td>
<td>4&quot;/6&quot;</td>
<td>6&quot; (8&quot;)</td>
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## Select Plasma Etch Capabilities

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<td>Ar, He</td>
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The importance of industrial lab usage is growing

History of re-charge income by research group:
Conclusions

• There are several mechanisms providing ready access to the UC Berkeley Microlab

• Industrial users benefit the lab as well member companies
  • affordable access for process development by start up companies
  • access to flexible tools for companies with rigid laboratory processes
  • financial support for lab maintenance and upgrade
  • student exposure to a commercial prospective