



**University of California, Berkeley
Microfabrication Laboratory**



**Berkeley Sensor
and Actuator Center**

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

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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

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**2 New Labs at California U.
 To Aid Integrated Circuitry**
 By RICHARD HENSHAW
Special to Electronic News

BERKELEY, Calif.—Research in semiconductor integrated circuitry by the Electronics Research Laboratory of the University of California, here, will be enhanced next Spring with the addition of two laboratories, Prof. D. C. Pederson, director of ERL, said last week.

He predicted that "substantially more than the current 10 per cent of ERL's total effort will be devoted to this area," when the new semiconductor integrated circuits fabrication laboratory and electron beam microscopy facility begin operating.

Professor Pederson was interviewed following a two-day closed meeting which reviewed for the supporting agencies, ERL's research efforts during the past year. He noted that during the next two years ERL will study the basic circuit functions which can be realized in integrated circuits and will try to understand the necessary interactions of properties needed to achieve, among other, oscillators and flip-flops.

In trying to achieve a circuit function without recourse to separate components, ERL will use the scanning electron beam microscope to inspect and study what goes on in an integrated circuit.

To absorb various integrated circuit technologies, Prof. Pederson and ERL has worked with, among others, Westinghouse Electric Corp., Youngwood, Pa., Motorola Corp., Semiconductor Division, Phoenix, and Fairchild Semiconductor, Mountain View, Calif.

Funds for research in integrated circuitry during the past 35 months have come from the Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson AFB, Dayton, O., and a tri-service contract. The latter was administered jointly by the Office of Naval Research, the Air Force Office of Scientific Research and the Department of the Army Research Office and Signal Corps.





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/Al₂O₃/Nb Josephson junction process



A sampling of reseach faculty

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

*Bioengineering @Chemistry/Chem. Engr. % Mat. Sci. & Engr. ^Mech. Engr. #Physics



A sampling of Microlab educational programs

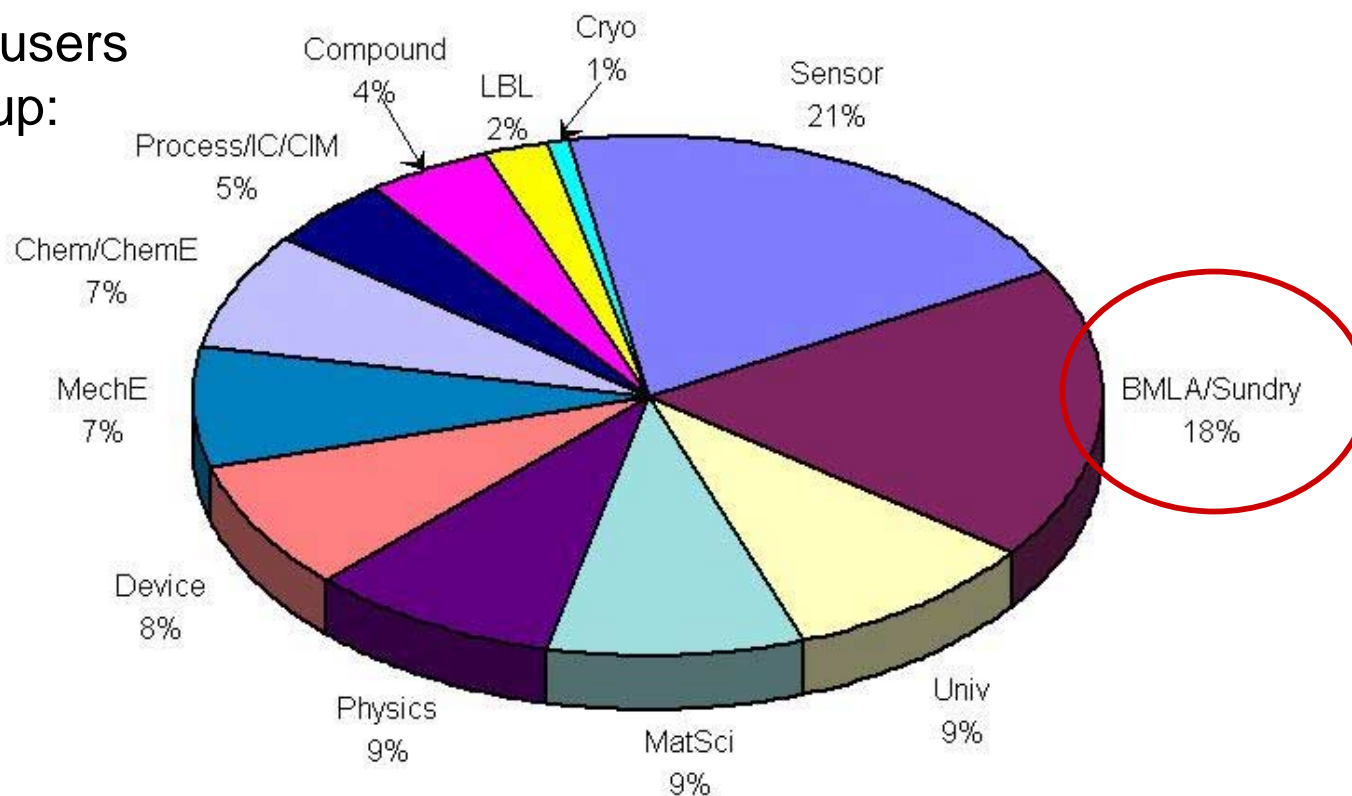
- **Support of laboratory courses**
 - EE143: Microfabrication Technology
 - C133 (ChE/ME/EECS): Microfabrication Equipment Lab
- **Graduate student training and research; seminars**
 - EE298-12: Solid-State Technology and Devices
 - EE298-24: Berkeley Sensor and Actuator Center Seminar
- **Undergraduate 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, Si_3N_4 , SiO_2
- 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 aligner, 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 wire 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>

- 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

Number of employees
per member company

Annual BMLA
membership fee

1	\$15K
2	\$25K
3-4	\$35K
5-6	\$50K

maximum of 6 employees
from any member company



BMLA Recharge Rates

Effective 7/1/02 – 6/30/03

University researcher
standard rates

Access Fee	\$83.70/month
Lab Fee	\$32.40/hour
Special Equipment	\$30.00/hour
Exceptional Equipment	\$34.00/hour
Staff Services	\$66.00/hour

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	MicroAssembly Technologies
Advanced Integrated Photonics, Inc.	MicroGen Systems, Inc.
Alien Technology Corp.	Molecular Reflections
Emitronix, Inc.	Nanochip, Inc.
The Fox Group, Inc.	Nanomix, Inc.
General Nanotechnology	NewPeregrine, Inc.
Integrated Nanosystems, Inc.	Network Photonics Inc.
Intel Corporation	Onix Microsystems, Inc.
Jet Propulsion Laboratory	Photon Imaging, Inc.
Luxnet Corporation	Progressant Technologies, Inc.
MEMS PI	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

	Lam1	Lam2	Lam3	Lam3	Lam4	Lam5
Platform	AutoEtch	AutoEtch	AutoEtch	Autoetch	Rainbow	Rainbow
Model	480	590	690	PLL	4400	9400
Wafer Size	4" / 6"	4"/6"	4"/6"	4"/6"	6" (8")	4" (8")
Poly					yes	yes
Oxide		yes				
Thick Nitride		yes				
Thin Nitride	yes				yes	
Al			yes			
Al passivate				yes		





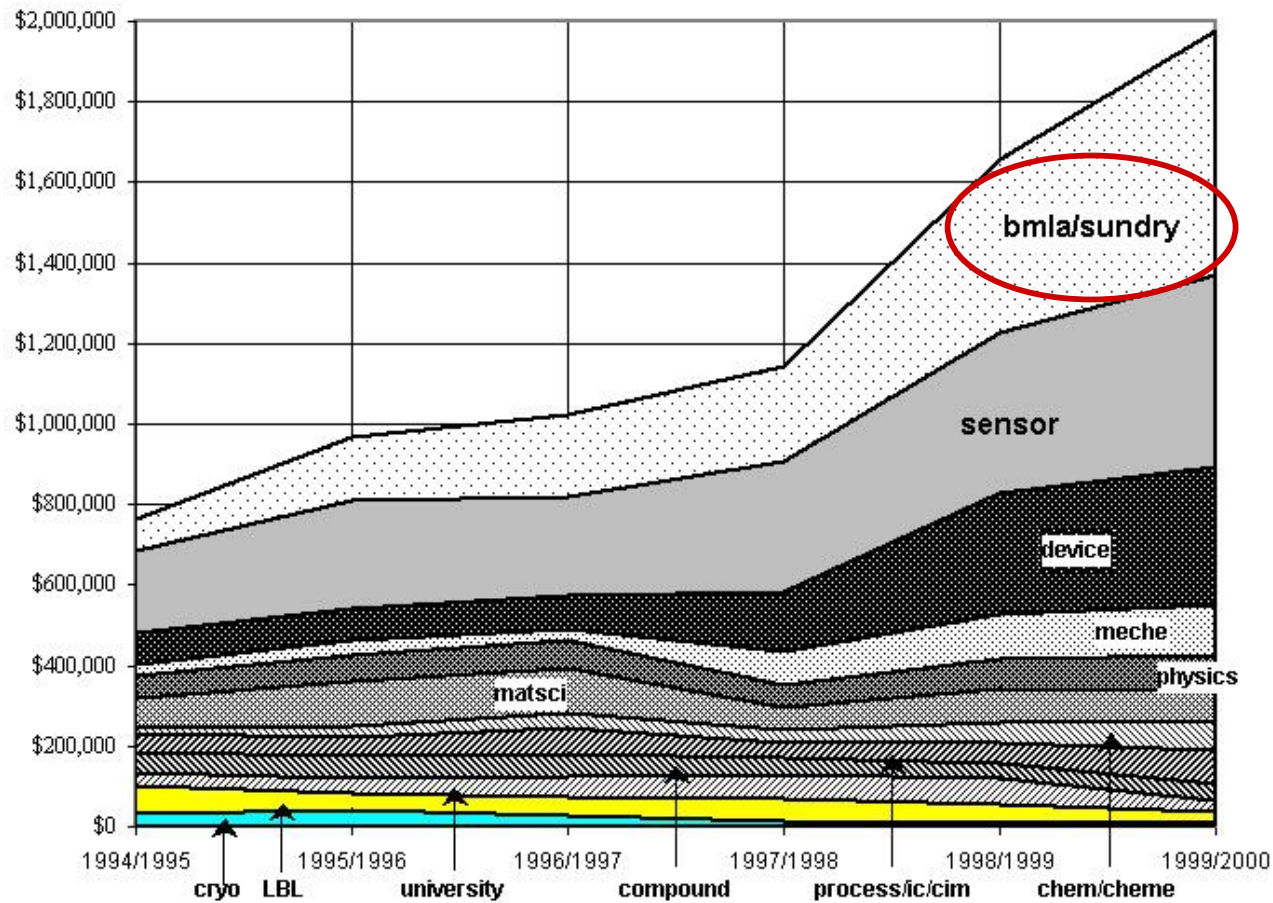
Select Plasma Etch Capabilities

Lam1	Lam2	Lam3	Lam3 PLL	Lam4	Lam5	STS	Ptherm
SF6			SF6	SF6	SF6	SF6	SF6
	CF4, CHF3		CF4	CHF3	CF4, CHF3	C4F8	CF4, CHF3
		BCl3					C4F8
		Cl2		Cl2	Cl2, HBr		
He	He			He	Ar, He clmp	He	Ar, He



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**