

# ***The Berkeley Marvell NanoLab***

**The History**

**The Specifics**

**The Capabilities**

**The Present**

**The Advantages**

**August 2024**

Bill Flounders, Ph.D.  
Professor Kristofer Pister, EECS

NanoLab Executive Director  
NanoLab Faculty Director





# *The History* *An Evolving Laboratory*

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

UC Berkeley EECS Professor,  
William G. Oldham



**...from Nanoscale Research to Gigascale Engineering...**



# *The History: Phase 1 Early ICs*

Faculty from EE share equipment to be able to conduct research in the new field of integrated circuits

## THE EVOLUTION OF THE BERKELEY MICROLAB

### Semiconductor Integrated Circuits Fabrication Laboratory, “The Old Lab” 1962 - 1982

In 1960, only months after some of the key patents on integrated circuit fabrication were filed, professors in the department of Electrical Engineering conceived plans for the country's first university IC lab. Working circuits, aligned by hand and fabricated on 3/4-inch-diameter silicon wafers emerged in 1962. As EECS Professor Emeritus David Hodges notes, *“It was pretty primitive in those days . . . but we got some working circuits . . . and we learned an awful lot!”*

Background: N-MOS op-amp. K. Burns/Prof. Paul Gray, 1976



Fabricated some of the earliest fundamental microelectronic devices  
high speed A/D converters, operational amplifiers

PABX line finder circuit (private automated branch exchange)  
- the basis of integrated services digital networks



# *The History: Phase 2, EECS to COE*

## *ICs to MEMS to new discrete devices*

**The shared equipment model is expanded, the faculty base grows, the recharge model is established, and external use is opened.**



**Microfabrication Laboratory,  
"The Microlab" 1983 - 2010**

The Microlab expanded the 1200 ft<sup>2</sup> Semiconductor Lab into a 10,000 ft<sup>2</sup> Class 100 clean room and greatly enhanced the department's research and teaching capabilities. The first graduate class in integrated circuit processing commenced in the fall of 1983. The Microlab demonstrated the commitment of EECS faculty to share research space and equipment. This model has become the standard for most university microfabrication facilities. Professor William Oldham described the advantage of this strategy, "*Having such a wide variety of technologies under one roof . . . fosters innovation.*"

Home of the First NSF/Industry University Cooperative Research Center (IUCRC)

The Berkeley Sensor and Actuator Center BSAC

Fabricated some of the first MicroElecroMechanical Systems (MEMS)

polysilicon based accelerometers, the basis of the airbag sensor,

electrostatically actuated micromotors

IC processed piezoelectric microphones

The world's smallest (Year 2000) gate length transistor (15nm)

One of the first finFET 3D transistors





# *The History: Phase 3, a cross campus facility Integrating Multiple Technologies*

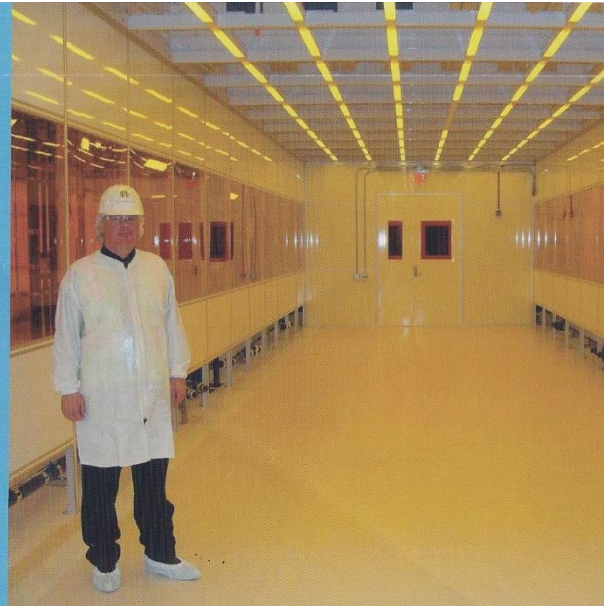
**A larger purpose built cleanroom is built after critical mass achieved; commercial use growing to 50% of cost recovery, but 25% of use**

## **Marvell Nanofabrication Laboratory, "The Marvell NanoLab" 2009 -**

The Marvell Nanolab is the next stage in Berkeley's shared laboratory evolution. It will provide 15,000 ft<sup>2</sup> of flexible Class 100 and Class 1000 clean room and support the broadest spectrum of nanotechnology research and education. The Marvell Nanolab is part of the new, multi-campus Center for Information Technology Research in the Interest of Society (CITRIS) initiative.

The formidable challenge before us is to move the entire operation from its home of more than 45 years in Cory Hall to the CITRIS headquarters, Sutardja Dai Hall. It is heartening that so many faculty, staff and friends recognize and support the importance of this enabling lab. Thank you to all who have contributed.

Under construction: a lithography bay of the new Marvell Nanolab with filtered yellow light for handling photo sensitive material



World's smallest laser (2009)

(Xiang Zhang, MechEng)

First demonstration of negative capacitance (Sayeef Salahuddin, EECS)

Development of nanomechanical transistor relays (Tsu-Jae King Liu, EECS)



# *The Specifics*

- 15,000 ft<sup>2</sup> (1400 m<sup>2</sup>) Class 100 Clean Room
- \$5M/year operating budget. 100% recharge recovery  
>50% from industry access affiliate program
- 80 Academic PIs; ~350 researchers/year  
~24 companies ; 80 researchers/year  
50,000 total use hours/year
- Enabling >\$40M/year in research funds
- The NanoLab provides research capabilities for faculty system wide. An efficiently run shared facility with a low barrier to entry.
- Affiliate program supporting many local startups .



# *The Capabilities*

## ● **Lithography**

Contact aligners, i-line and 248nm stepper, backside capable, 130 kV e-beam to 7nm, 7 coat /develop tracks, UV hard bake

## ● **Deposition**

ALD, PECVD, LPCVD: SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, poly-Si and SiGe, epi Si and Ge  
Unique: LACVD, SiC, AlN, diamond, Mo, Ru, 6 evap, 7 sputter

## ● **Etch**

16 plasma systems including DRIE Si, ICP 3/5, ICP metal, XeF<sub>2</sub>, HF vapor, KOH, TMAH, Critical Point Drying

## ● **Planarize, Package**

Si, SiO<sub>2</sub>, metal CMP; dicing, wafer bond, flip chip bond, die bond, Au and Al wire bond, parylene encapsulation

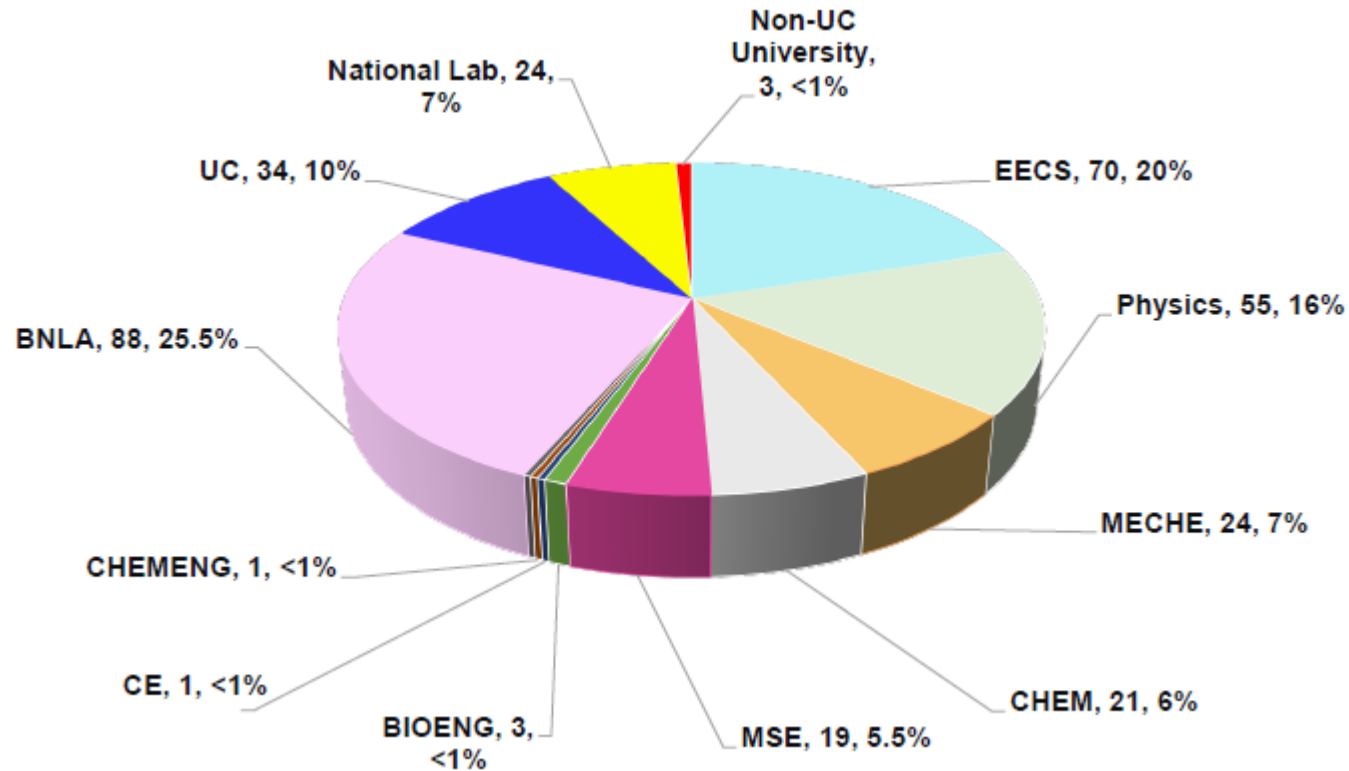
## ● **Metrology**

SEM, AFM, XRD, EDX, reflectometer, contact + optical profilometer, interferometer, FTIR, spectroscopic ellipsometer, Raman scope

# The Present

# Membership is Strong and Stable

*Labmembers by Department FY23*



Fiscal Year	2018	2019	2020	2021	2022	2023
Total	382	376	342	304	329	343
UCB	257	241	217	191	189	194
Commercial	73 (19%)	84 (22%)	73 (21%)	72 (24%)	82 (25%)	88 (26%)
All Academic	309	292	269	232	247	255
External	125 (33%)	134 (36%)	125 (37%)	113 (37%)	140 (43%)	149 (43%)



# The Present

## An active affiliate company program



A.M. Fitzgerald  
& Assoc., LLC



Adriatic Research  
Institute

ANYON TECHNOLOGIES

CEITTA



BW10 Inc.

Bandwidth 10, Inc.

IMAGIA

inSync  Mirror

iota BIOSCIENCES  
powered by Astellas

Enertia Micro



Nanoshift Consulting Group

LIMINA TECHNOLOGIES LLC



Nano Precision Medical, Inc.



Ψ PsiQuantum

n·eye  
2600 Tenth Street Suite 402  
Berkeley, CA 94710

PrecisionNeuroscience

rigetti

Science

PIVOTAL  
SYSTEMS

Sonera 

Serinus LABS

TEXAS INSTRUMENTS

# *The Present*

## *Advantages for Academic Researchers*

- **More efficient use of valuable laboratory space and specialized research equipment**
- **Significant improvement in quality of support; researchers focus upon results not maintenance**
- **Maximum PI research flexibility integrating strategically selected, diverse cutting edge capabilities around a stable silicon baseline**
- **Wide diversity of research leads to enhanced research cross fertilization**
- **Earliest possible interaction with start up companies**

# *The Present*

## *Advantages for a VC funded startup*

- **Cleanroom with wide range of process equipment is immediately available.**
- **5 photoresist systems characterized and maintained  
Immediate mask making capability**
- **No application and wait for city and county chemical handling permits**
- **Compare multiple technologies prior to equip purchase**
- **Well defined research expenses during prototype phase**
- **Facility access agreement only**
  - **Ensures separate IP and no revenue or equity sharing**



**For any Lab related questions, please contact:**

**Marvell NanoLab Executive Director**

**Dr. Bill Flounders**

**bill at eecs.berkeley.edu**

**or**

**Marvell NanoLab Faculty Director**

**EECS Professor Kris Pister**

**pister at eecs.berkeley.edu**

***Thank You !***