NNCI @ Stanford

Bruce Clemens, Professor of Materials Science & Engineering, Director of Stanford Nano Shared Facilities (SNSF)

Co-PIs:

Curt Frank, W.M. Keck, Sr. Professor in Chemical Engineering

Kate Maher, Assistant Professor of Geological and Environmental Sciences

Beth Pruitt, Associate Professor of Mechanical Engineering and, by courtesy, of Molecular and Cellular Physiology

Key Participants:

Tobi Beetz, Associate Director of Stanford Nano Shared Facilities (SNSF)

Mary Tang, Associate Director of Stanford Nanofabrication Facility (SNF)

Roger Howe, W.E. Ayer Professor of Electrical Engineering, Director of Stanford Nanofabrication Facility (SNF)

nano@stanford supported by NSF award ECCS-1542152

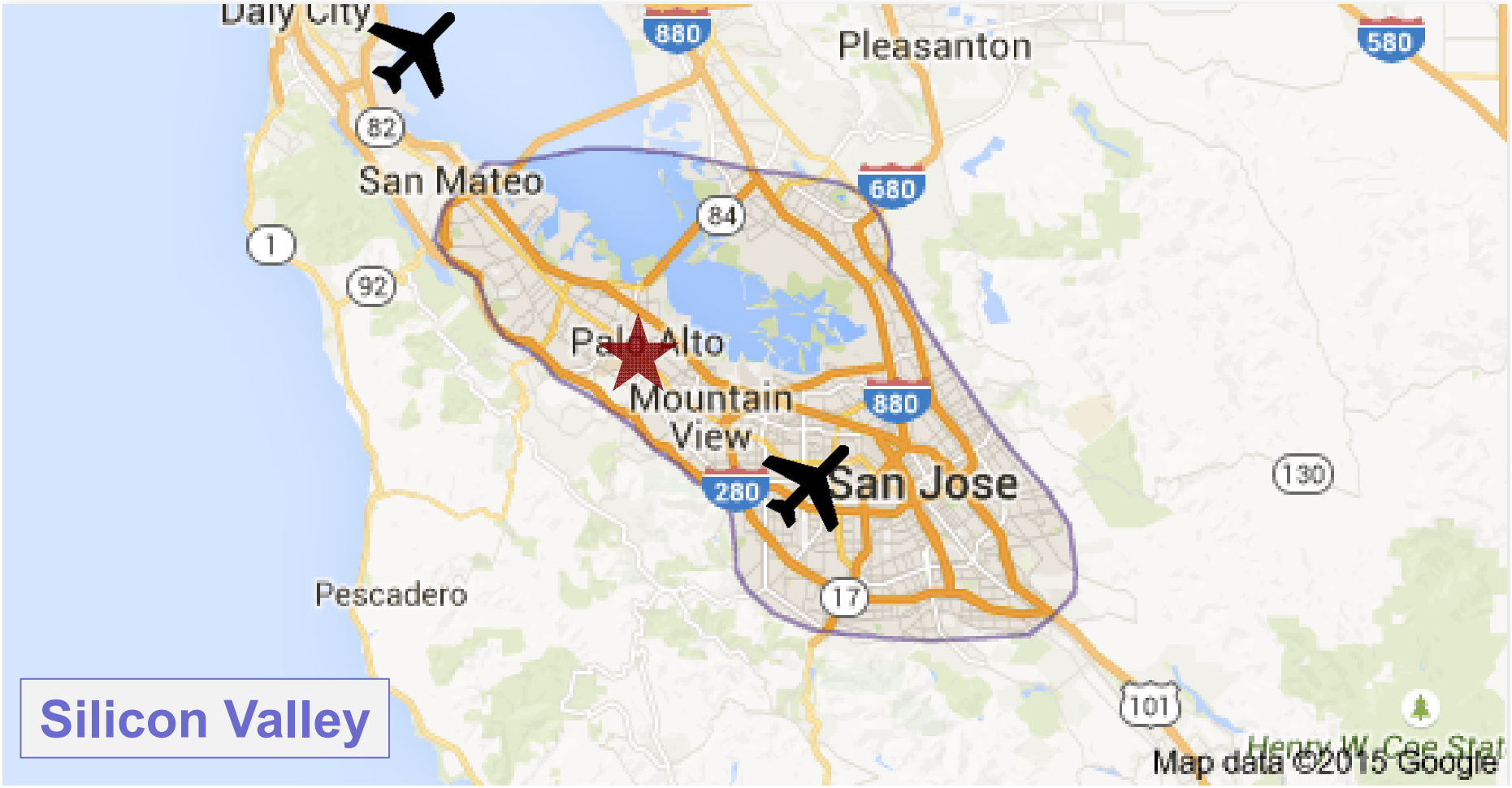
National Nanotechnology Coordinated Infrastructure

NNCI @ STANFORD

Provide **access** to world-leading facilities and expertise in nanoscale science and engineering for internal users and for external users from academic, industrial, and government labs.

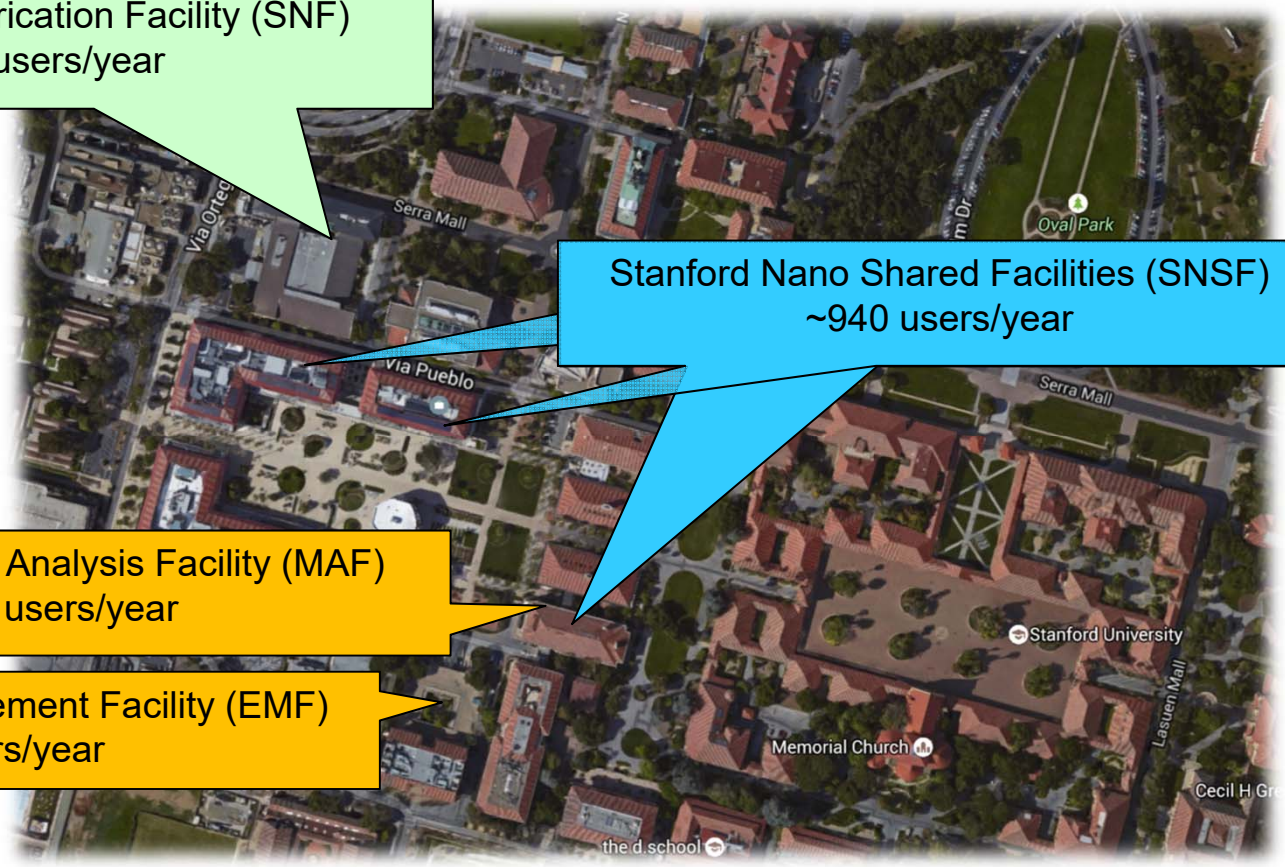
Develop and propagate a national model for **educational practices** that will help students and visitors become knowledgeable and proficient users of the facilities.

Location


Daly City
880
Pleasanton
580
82
San Mateo
680
84
1
92
Palo Alto
Mountain View
880
280
San Jose
130
Pescadero
17
101
Silicon Valley
Map data ©2015 Google

Facilities

Stanford Nanofabrication Facility (SNF)
~ 440 users/year



Stanford Nano Shared Facilities (SNSF)
~940 users/year

Stanford Mineral Analysis Facility (MAF)
~25 users/year

Environmental Measurement Facility (EMF)
~160 users/year

~30,000 ft^2

Facilities

Stanford Nanofabrication Facility (SNF)
~ 440 users/year

Nanofabrication

- **Previously supported through NNIN**
- 10,500-square-foot Class 100 cleanroom
- full suite of tools supporting device fabrication
- unique and rare tools: MOCVD (GaAs, GaN), epitaxy, CNT furnaces, graphene deposition




Facilities

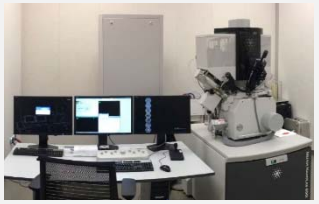
Stanford Nano Shared Facilities (SNSF)
~940 users/year

Previously NOT supported through NNIN

Nanofabrication

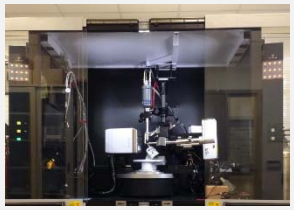

- Advanced fabrication centered around **JEOL 6300 e-beam** lithography
- Flexible cleanroom

Electron & Ion Microscopy


- Full suite of characterization
- Unique and rare: **FEI aberration-corrected Titan Environmental TEM**, FEI Helios 600i dual-beam FIB/SEM (acquired with NSF support)

X-ray & Surface Analysis

- Unique and rare: **Cameca NanoSIMS 50L** (NSF sup.), **Scanning SQUID microscope** (NSF sup.),

Soft & Hybrid Materials Facility

- fundamental research on soft materials and their integration with hard materials and devices

Facilities

Previously NOT supported through NNIN

Stanford Mineral Analysis Facility (MAF)
~25 users/year

Mineral Analysis Facility



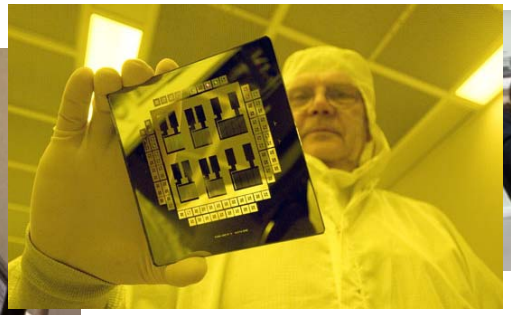
- Focused on characterizing minerals, rocks, and other inorganic materials
- Key: electron microprobe (NSF sup.)

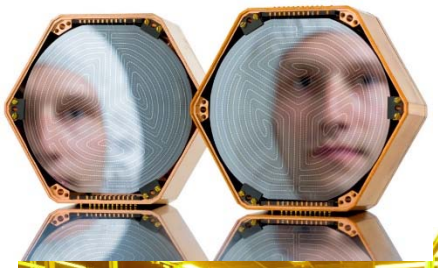
Environmental Measurement Facility (EMF)
~160 users/year

Environmental Measurement Facility


- Supporting soil, gas, and water measurements

Expertise



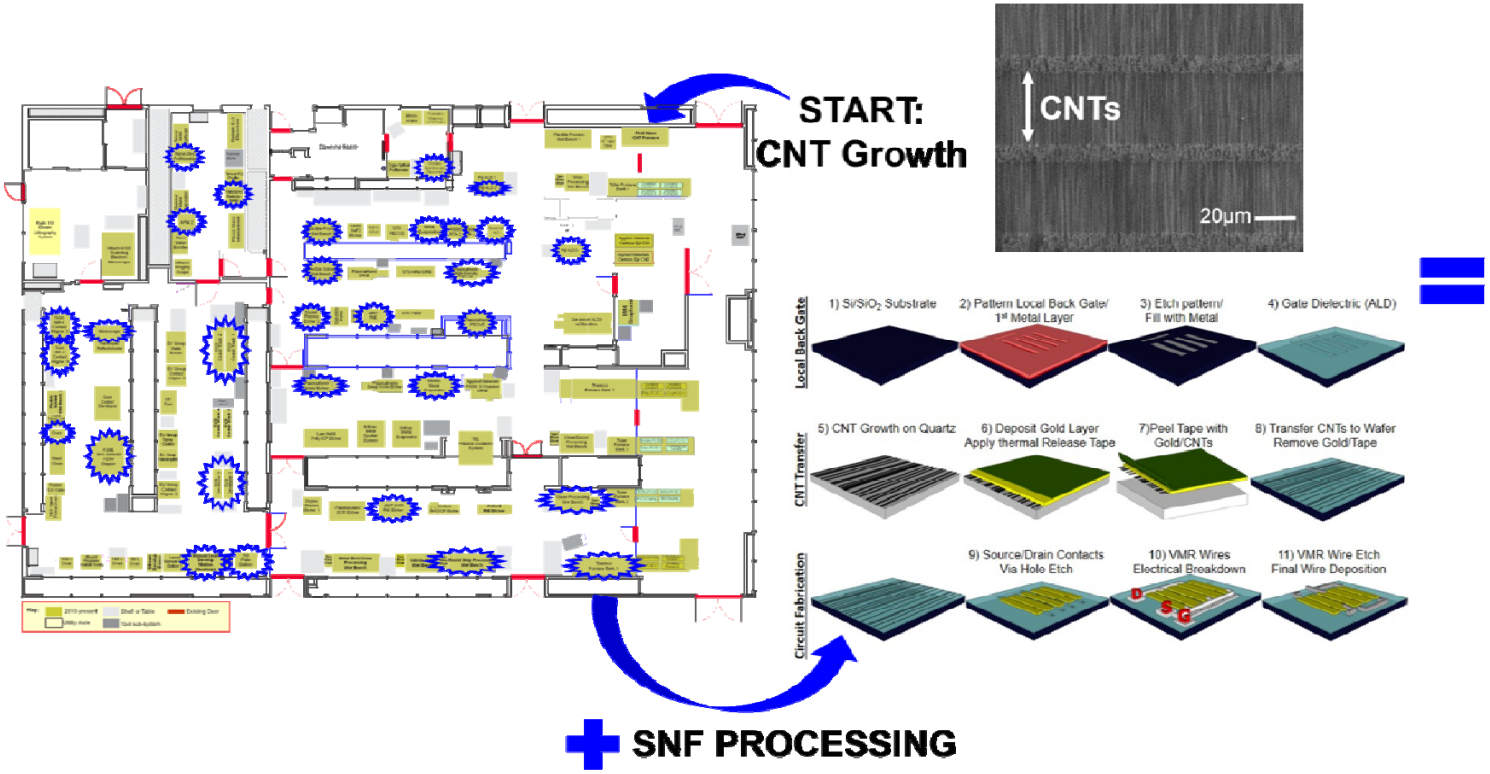


35 expert staff members

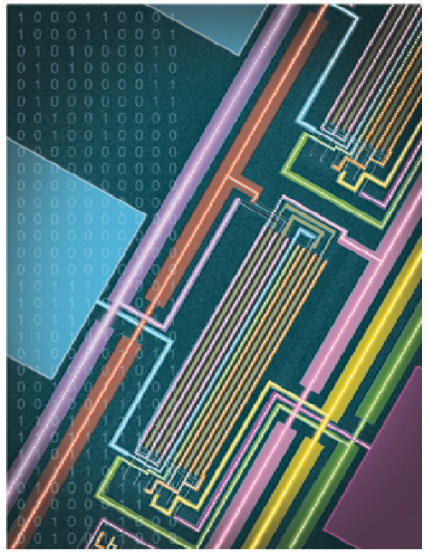
~170 faculty members

5 deans

Expertise

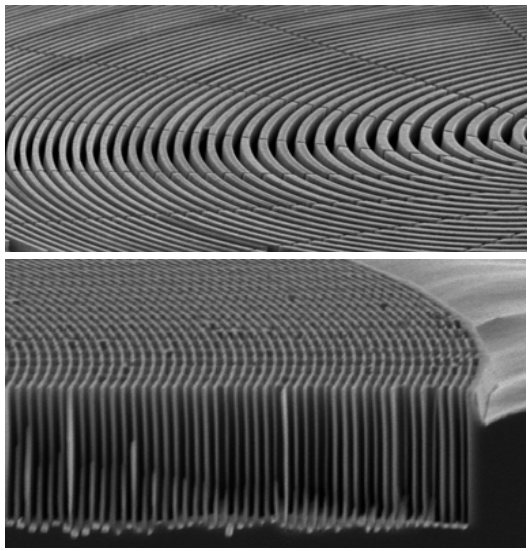


CNT Computer



M. M. Shulaker, *et al*, *"Carbon Nanotube Computer." Nature* 2013

Expertise



Optics and Nanostructures for Synchrotrons and FELs

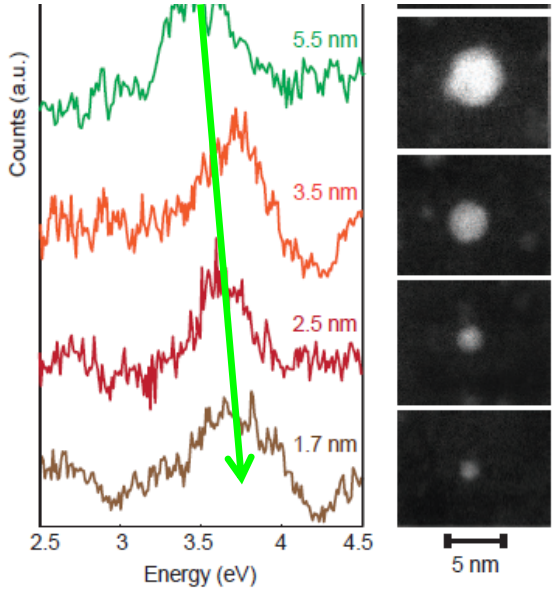
Ultrahigh aspect ratio, 3D x-ray diffractive nanostructures enables high resolution, high efficiency manipulation of hard X rays. High-resolution e-beam patterning to enable small feature sizes.

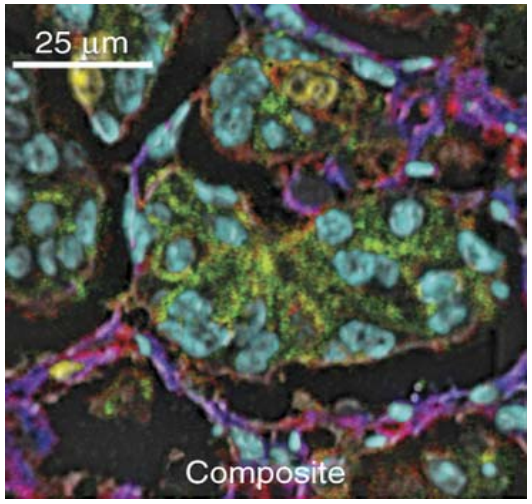
Dr. A. Sakdinawat Group (SLAC/X-FEL)

Correlation of quantum plasmon resonances of individual metallic nanoparticles to their size

Transmission Electron Microscopy combined with Electron Energy Loss Spectroscopy

Prof. J. Dionne Group - *Nature* **483** (2012)



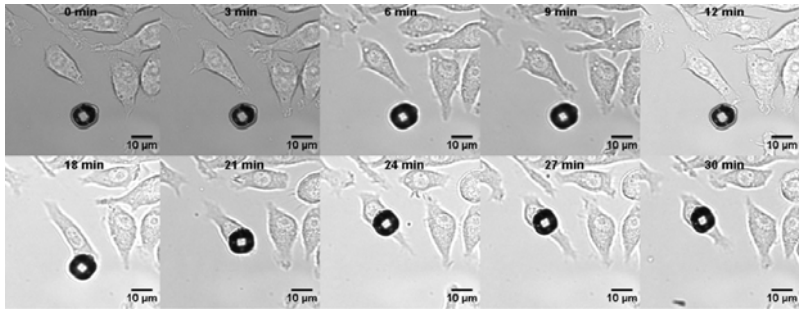


Medical Diagnostic: Multiplexed NanoSIMS imaging of human breast tumors

Method uses secondary ion mass spectrometry to image antibodies tagged with isotopically pure elemental metal reporters

Prof. G. Nolan Group - *Nature Medicine* **20** (2014) doi:10.1038/nm.3488

Expertise



Nanobiosensors to detect chemical changes in the human body for diagnosis and continuous in vivo monitoring

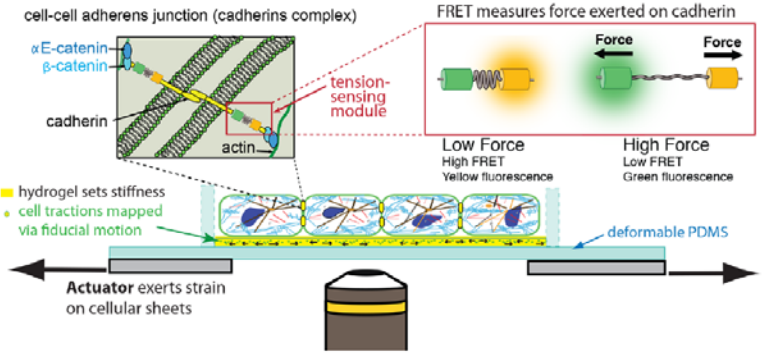
Demonstrated mass fabrication of micron-sized devices and inserted them into single cells

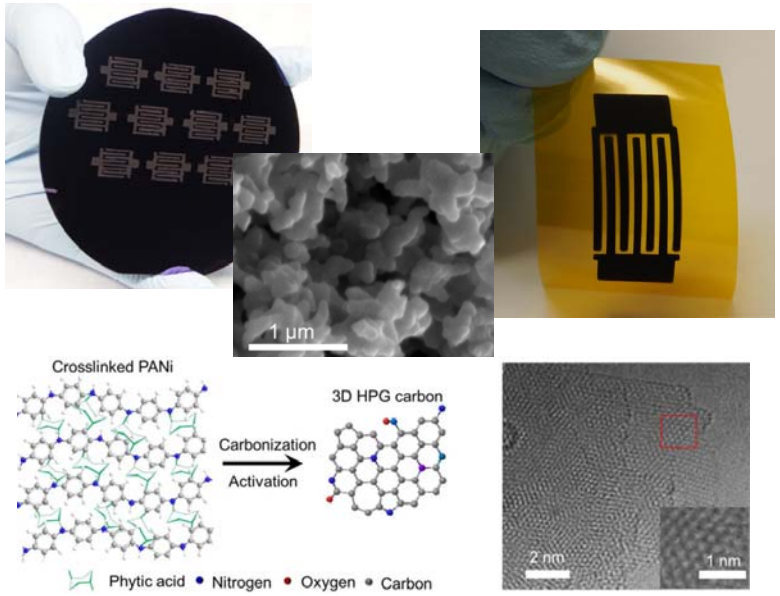
Profs. H.-S. P. Wong & Z. Bao Groups - *Nature Communications* **5** (2014), DOI: /10.1038/ncomms6028
Scientific Reports, **3** (2013), DOI: 10.1038/srep02295

Mechano-Transduction: From Molecules to Tissues

MEMS devices to study the role of mechanics in cell function, differentiation, and morphology

Prof. B. Pruitt Group - *PLoS Biology* **12** (2014), DOI: 10.1371/journal.pbio.1001996





Ultrahigh Surface Area 3D Porous Graphitic Carbon for Energy Applications

Demonstrated fabrication from conjugated polymeric molecular framework exhibiting high electrical conductivity, very high electrochemical activity at high mass loading, and high stability

Prof. Z. Bao Group - *ACS Cent. Sci.*, ***1*** (2015), DOI: 10.1021/acscentsci.5b00149

Education

- The knowledge of the users is the rate-limiting factor that controls scientific and technological progress in shared nanofacilities.

- Develop and propagate a national model for educational practices.

Stanford
Vice Provost for Teaching & Learning

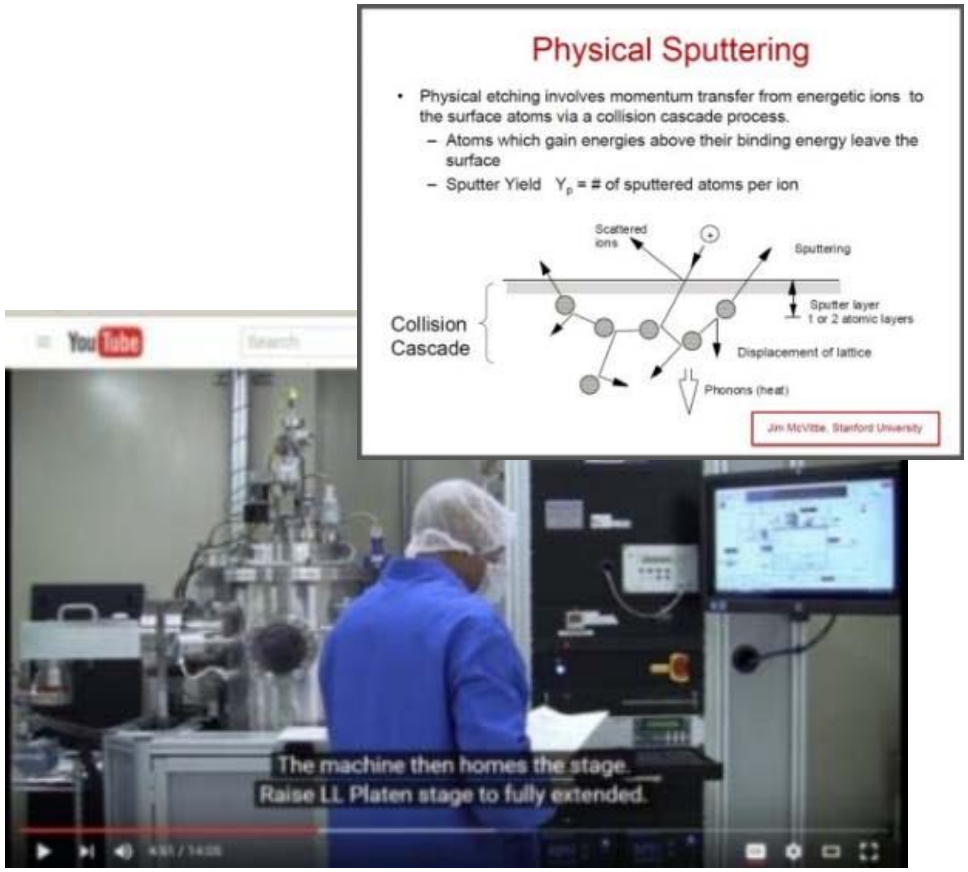
nanoHUB

Education

- Modules on
  - Fabrication & Characterization Fundamentals
  - Tool/Process specific

- Overview for this course
- Equipment List & Comparison
- Background
- Operational Procedures
- Training / Access

  How to get trained as a JEOL user
- Troubleshooting / Quick Fixes
- Recipes



Emphasis on universal content so that materials can be shared

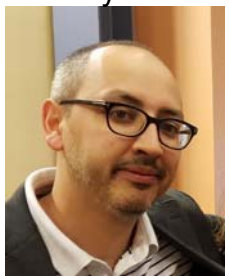
Education

- **Partnership with Cal State LA and Cal State East Bay (**minority-serving institutions) to develop and pilot best practices**.**

CALIFORNIA STATE UNIVERSITY EAST BAY

Ryan Smith
Physics

James Tandon
Physics

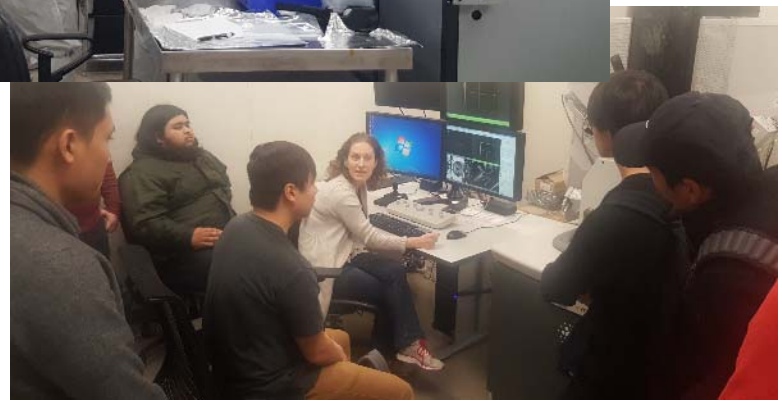


CAL STATE

Oscar Bernal
Physics

Winter 2015 CSUEB ranked:

- most diverse University in California
- 5th diverse Nationwide



- Background presentations
- Hands-on lab time
- Future:
  more immersive lab experience for class projects

Summer Institute for Middle School Teachers (SIMST)

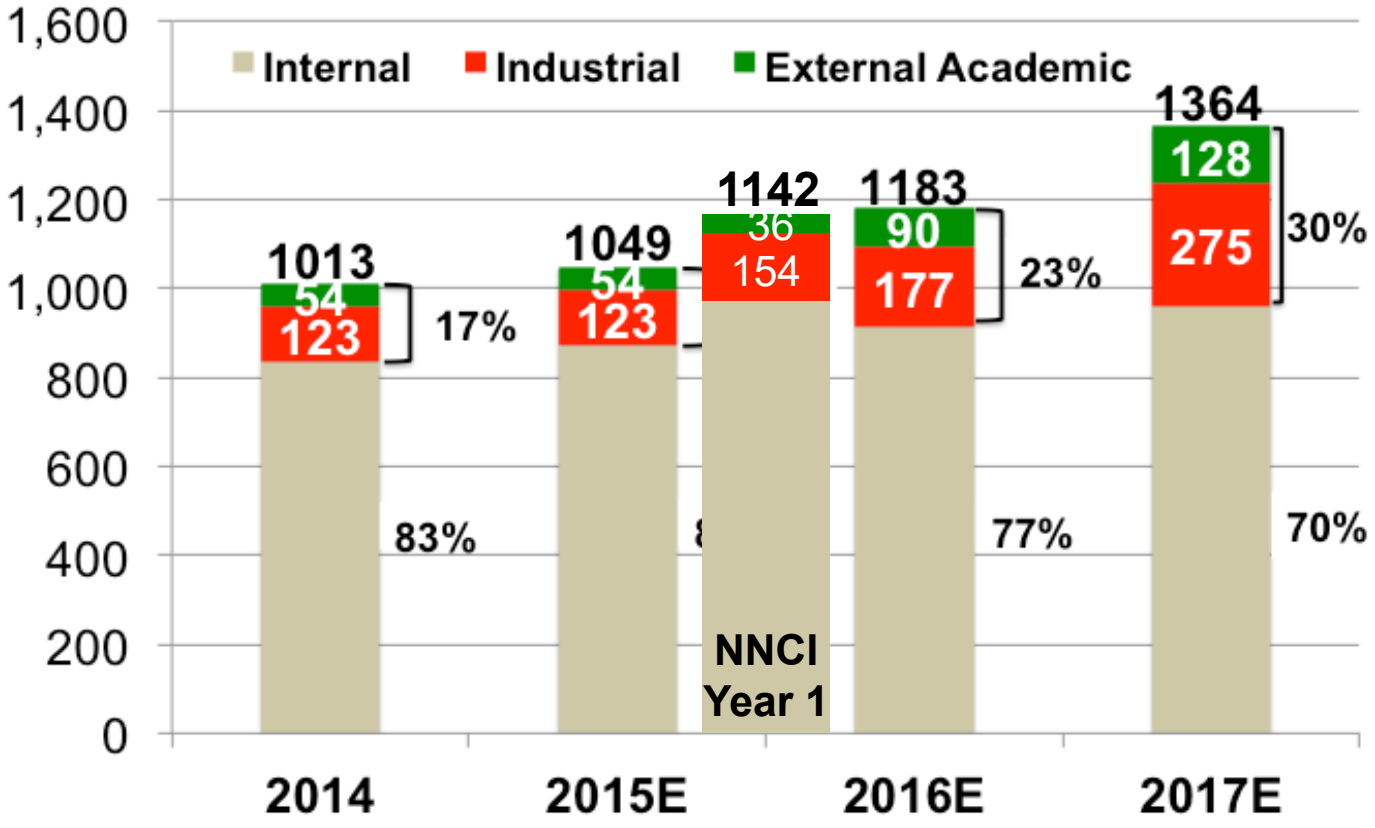
- Why focus on teachers?
  - Broad impact: teachers impact many students each year
  - Continued education – teacher retention
- Why focus on Middle School?
  - Critical age when students loose their natural interest in science
- Format
  - 3-day summer school for 15 teachers
  - Presentations, hands-on activities, lab tours, instrumentation demos
  - Teachers develop lesson plans incorporating hands-on activities
  - Stipend paid for participation
  - Stipend paid after implementation and reporting of lesson plan

First NNCI SIMST:
Summer 2017

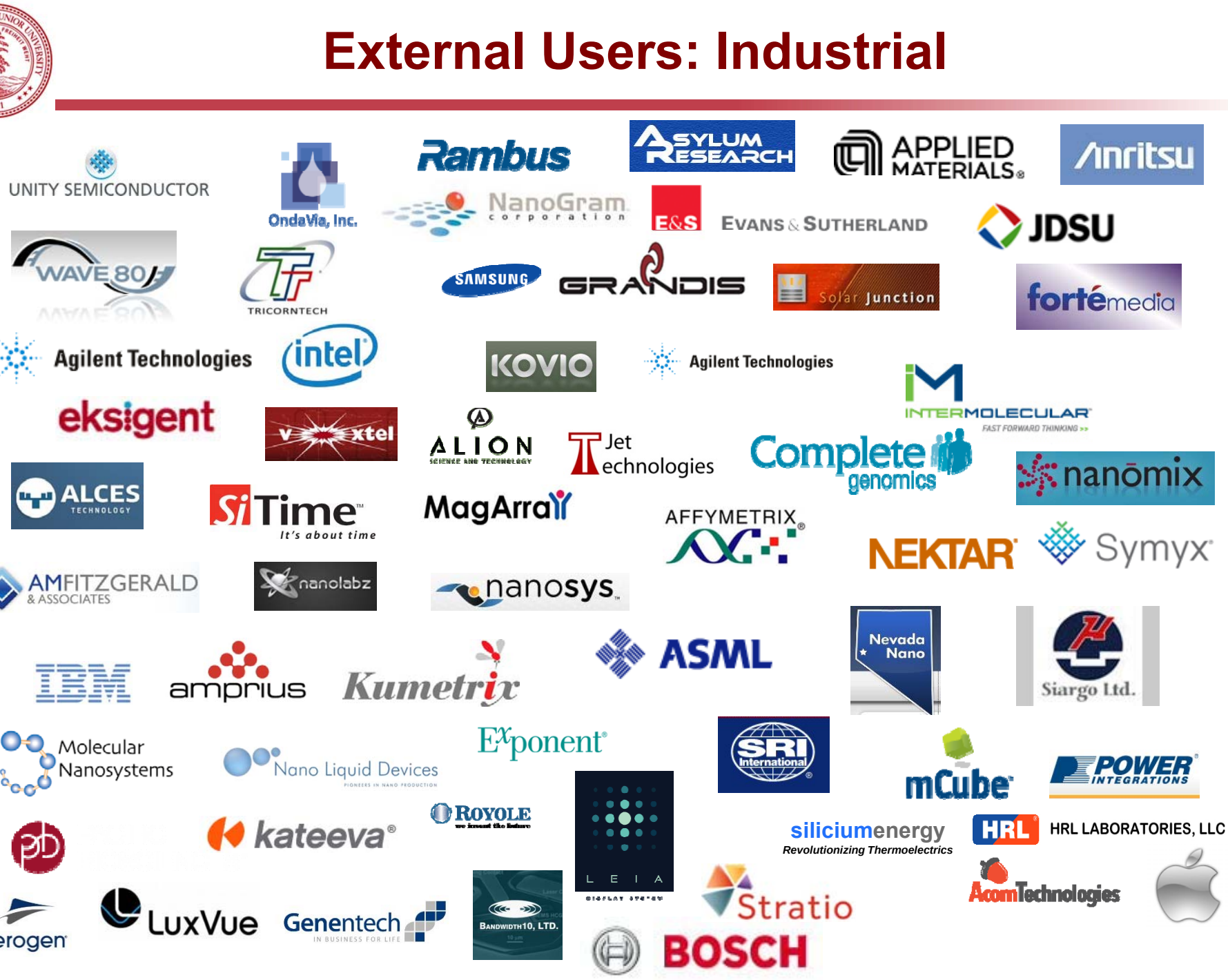
Images from previously NSF-funded NSEC where SIMST was initiated

External Users

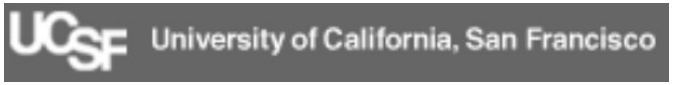
Goal: increase the percentage of external users from 17% in 2014 to 30% in 2017

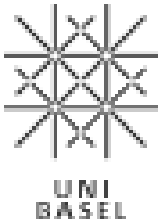


External Users: Industrial



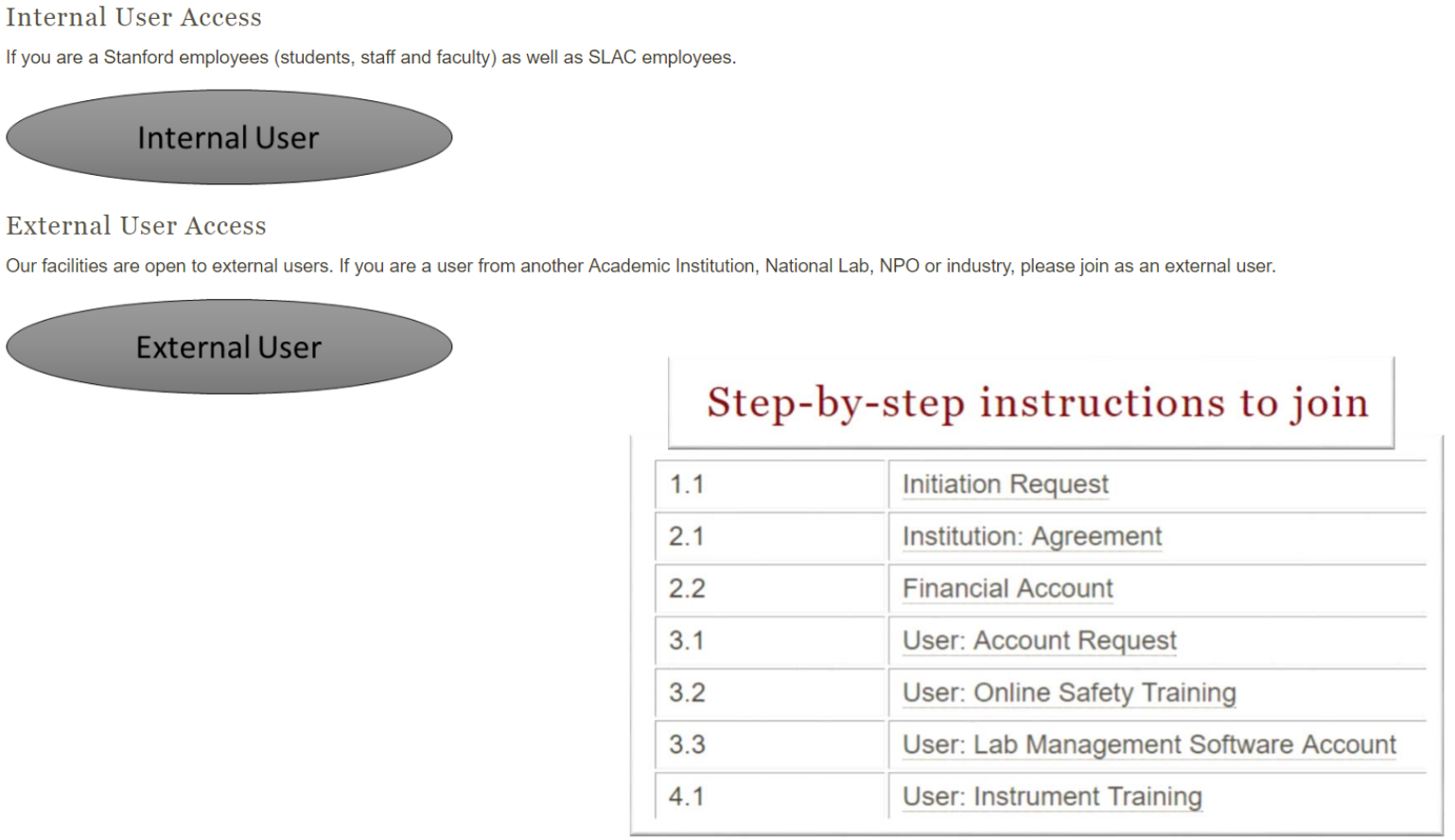
External Users: Academic





Redesigned External User Intake Process

- Assigned single point of contact
- Walks external users through the process step-by-step
- Provides tracking document to allow external users check on status of lab membership



NNCI-enabled new hires

- Dr. Shiva Bhaskaran
  - External Users

- Single point of contact throughout sign-up process and usage
- Facilitate interactions with staff
- Find potential new users

- Start: June 2016

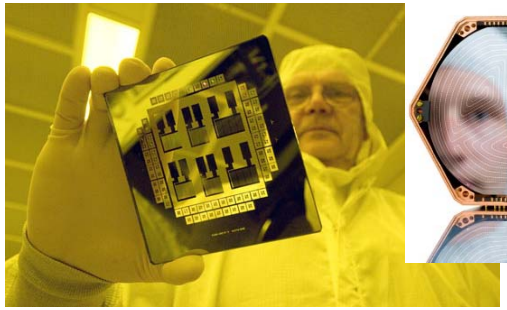
- Dr. Angela Hwang
  - Education & Outreach

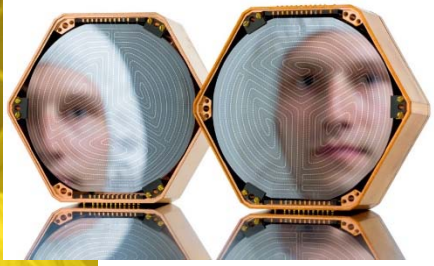
- Just-in-time teaching
- Summer Institute for Middle School Teachers
- Outreach events

- Start: Feb 2017

nano@stanford

nano@stanford provides access to world-leading facilities and expertise in nanoscale science and engineering for internal users and for external users from academic, industrial, and government labs.

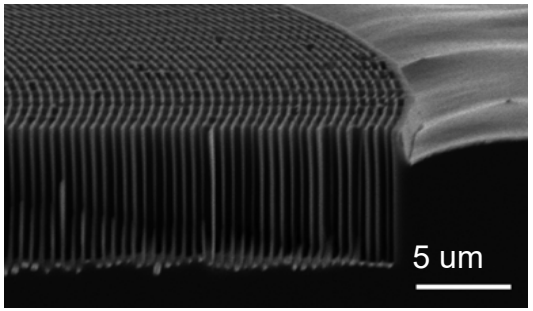


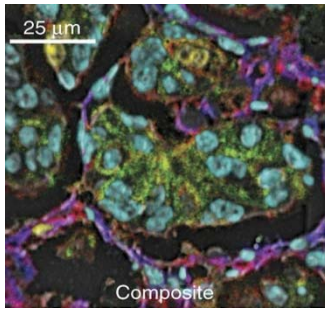


Over 1,100 annual users take advantage of a comprehensive array of advanced nanofabrication and nanocharacterization tools available within the Stanford Nano Shared Facilities (SNSF), the Stanford Nanofabrication Facility (SNF), the Mineral Analysis Facility (MAF), and the Environmental Measurement Facility (EMF).

Facilities feature:

- ~16,000 sqft fully equipped cleanroom facilities, including resources that are not routinely available, such as an MOCVD and advanced e-beam lithography
- ~15,000 sqft of characterization facilities, including SEM, TEM, FIB, XRD, SPM, XPS and unique tools such as a NanoSIMS, and a scanning SQUID microscope.





Broad research portfolio spanning traditional nano areas as well as life science, medicine, and earth and environmental science. Education and outreach programs, including a library of just-in-time educational materials, seminars, public events and tours.

http://nanolabs.stanford.edu

nano@stanford is supported by the National Science Foundation as part of the National Nanotechnology Coordinated Infrastructure under award ECCS-1542152.