NNCI @ Stanford

BRUCE CLEMENS

PROFESSOR OF MATERIALS SCIENCE &ENGINEERING

DIRECTOR OF STANFORD NANO SHARED FACILITIES (SNSF)

nano@stanford

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.

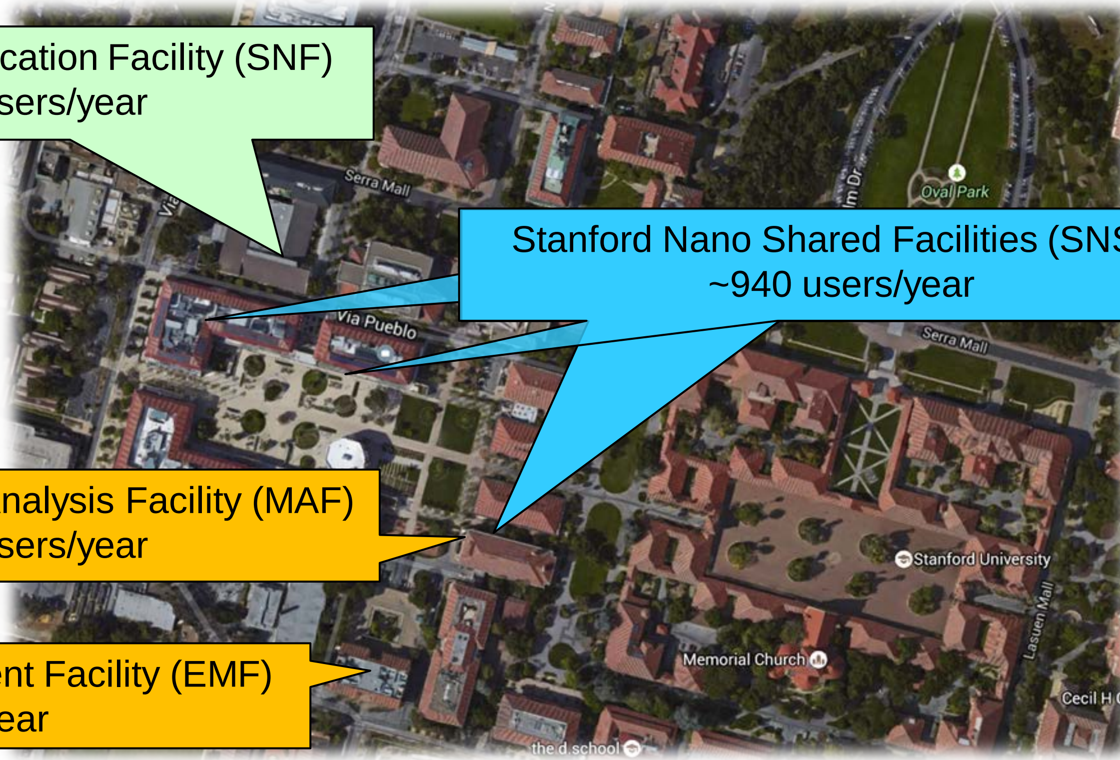
Facilities

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 ft²

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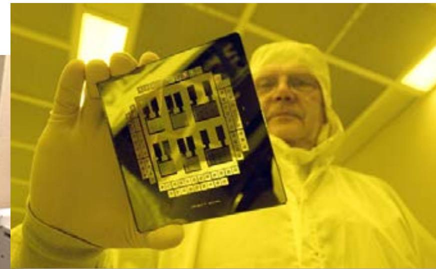
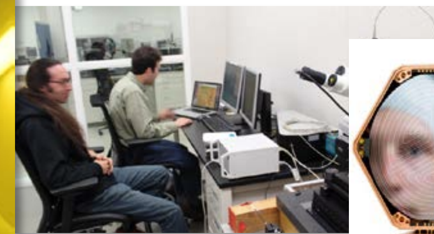
Expertise


35 expert staff members

~170 faculty members

5 deans





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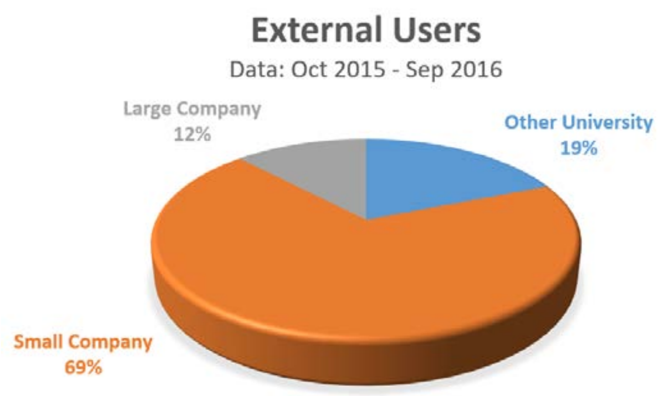
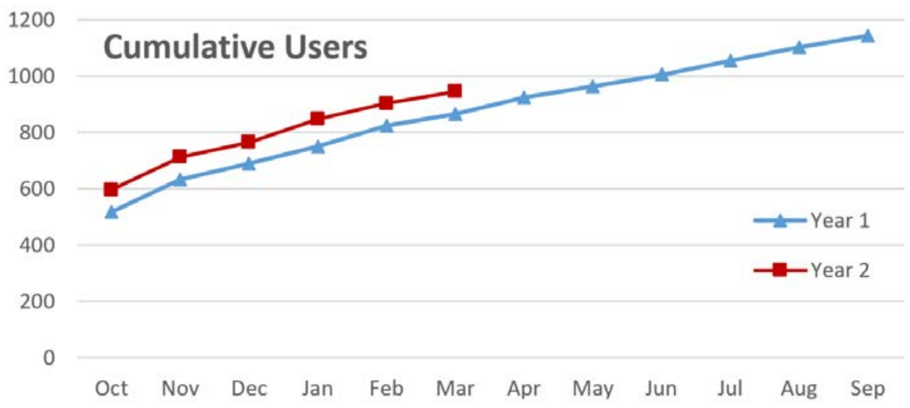
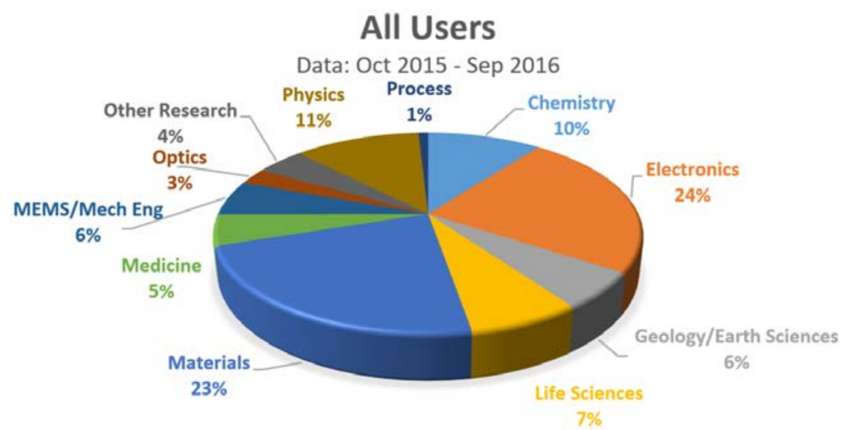
Stanford Site User Data

Yearly User Data Comparison		
	Year 1(12 months)	**Year 2 (6 months)**
Total Users	1142	945
Internal Users	952	791
External Users	190 (17%)	154 (16%)
Total Hours	113,089	52,288
Internal Hours	94,996	41,963
External Hours	18,093 (16%)	10,325 (19%)
Average Monthly Users	520	549
Average External Monthly Users	74 (14%)	82 (12%)
New Users	542	232
New External Users	89 (16%)	42 (18%)







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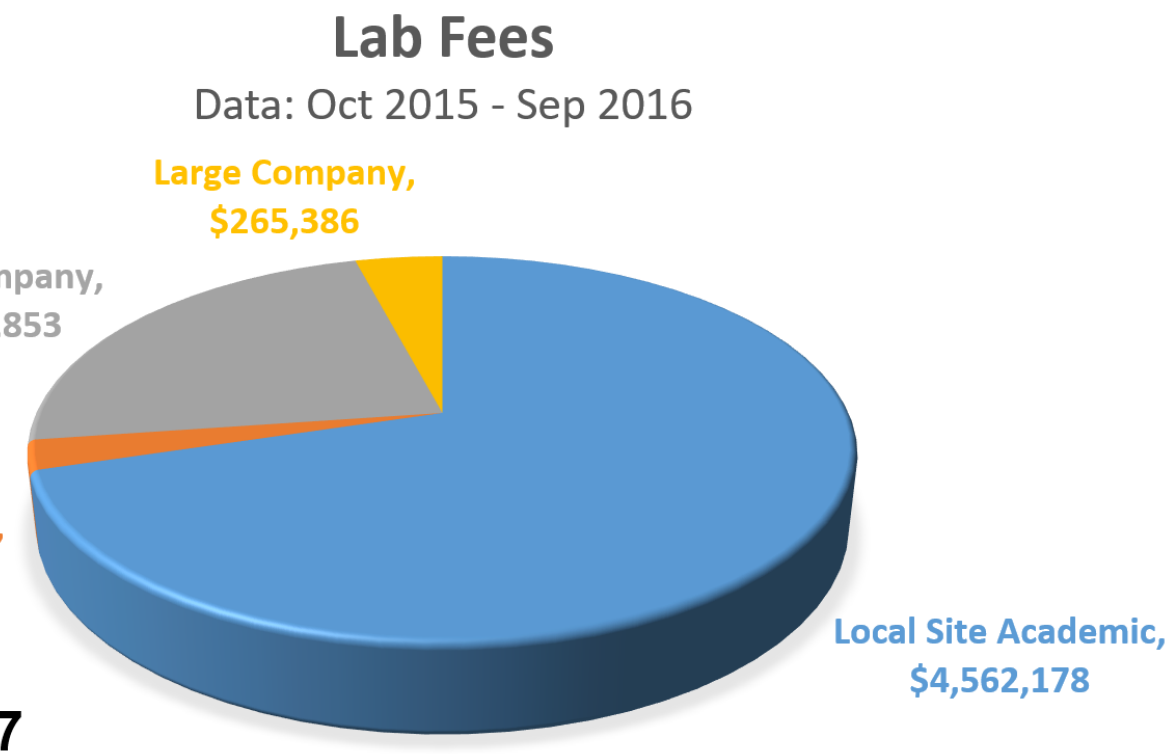
Users: Lab Fees – 1st Full Year



Total: $6,492,627

Sampling of external user affiliations

ACORN TECHNOLOGIES
Aerogen
a
ARIA PHOTONICS
Bandwidth10
BD
bioCURIOUS
BOSCH
Carbon
中国科学院 CHINESE ACADEMY OF SCIENCES
CONFLUENT
SRI International
COOPER Bussmann
DAIKIN
Fine Arts Museums of San Francisco
Genentech
GRANDIS
HALO INDUSTRIES
Roche
USGS science for a changing world
hp
HONDA
illumina
INTERMOLECULAR FAST FORWARD THINKING
INX
RayVio
IONpath
JSR Micro JSR MATERIALS INNOVATION
KOLO
Lam RESEARCH
LOCKHEED MARTIN
Paradromics
CLSA California Life Sciences Association
MagArray
nanoprecision medical
AMES RESEARCH CENTER
NASA
NORTHROP GRUMMAN
mOasis Innovative crop science
SAMSUNG
epic
PACBIO
TE connectivity
QuantumScape
parc A Xerox Company
Pivot Bio
PRIMENANO ACCELERATING THE NANO ERA
Quantapore Inc.
SINOVIA TECHNOLOGIES
tactus
rigetti
Sandia National Laboratories
Santa Clara University
SEEO
SF STATE
twoporeguys
UNIVERSITY OF CALIFORNIA SANTA CRUZ
Berkeley UNIVERSITY OF CALIFORNIA
TEXAS The University of Texas at Austin
WD Western Digital
WESTERN MICHIGAN UNIVERSITY

Currently ~140 active organizations!

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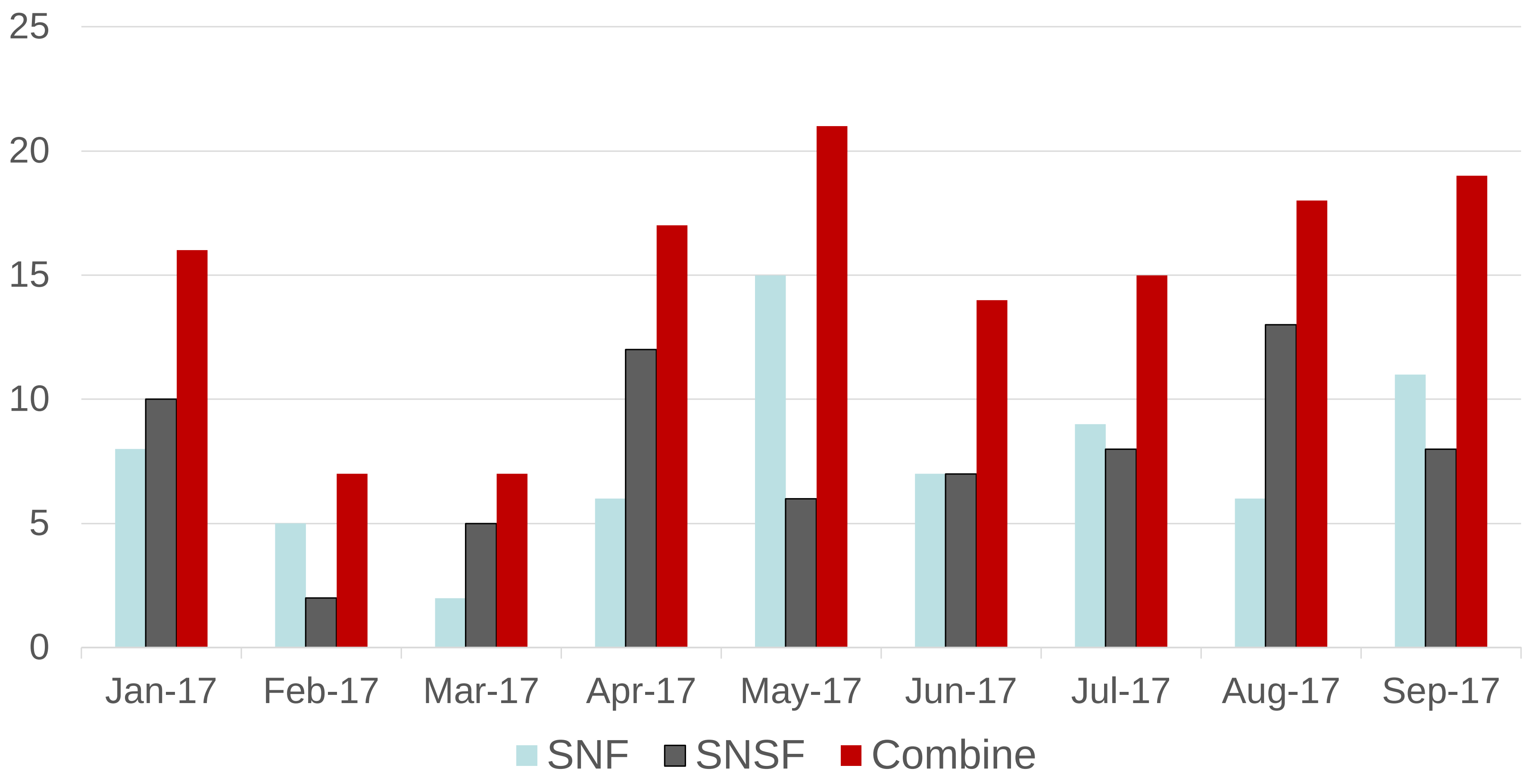
New External Users 2017



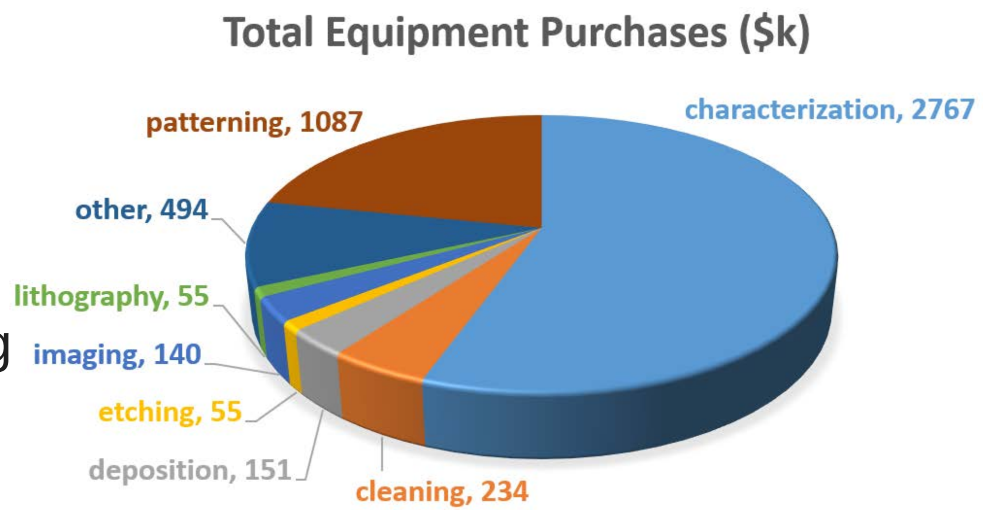
Sampling of new external user affiliations in 2017

- Asterias Biotherapeutics
- BioCellection
- Active Layer Parametrics
- Buck Institute for Research on Aging
- California State University East Bay
- Paradromics
- Applied Ceramics
- Akhan Semiconductor
- Cañada College
- Capacitor Sciences
- Centrillion Technologies
- Enablence
- Enovix
- Muse Bio
- Phonak
- Qool Therapeutics
- Fudan University
- SJSU
- Cornell University
- Kateeva
- GraeaeX
- Mellanox Technologies
- University of California Merced
- inSense
- KLA Tencor
- Malachite Technologies
- Montana State University
- Waymo
- Modern Electron
- Sinovia Technologies
- NICE National Institute of Clean-and-Low-Carbon Energy 北京低碳清洁能源研究所
- Ubiquitous Energy
- Prism Inks, Inc.
- Spectra-Physics, A Newport Company
- Sensel
- ProbeLogic
- Verily

~ 51 new active organizations!

Facility Upgrades and New Tool Capabilities

- Since start of NNCI:
  - ~$5M equipment
- Source
  - ~$0.7Mk NSF MRI (XCT)
  - ~$4.3M University funding



Heidelberg MLA150 Direct Write System

Leybold RF/DC sputter station

Nanoscribe 3D printing system

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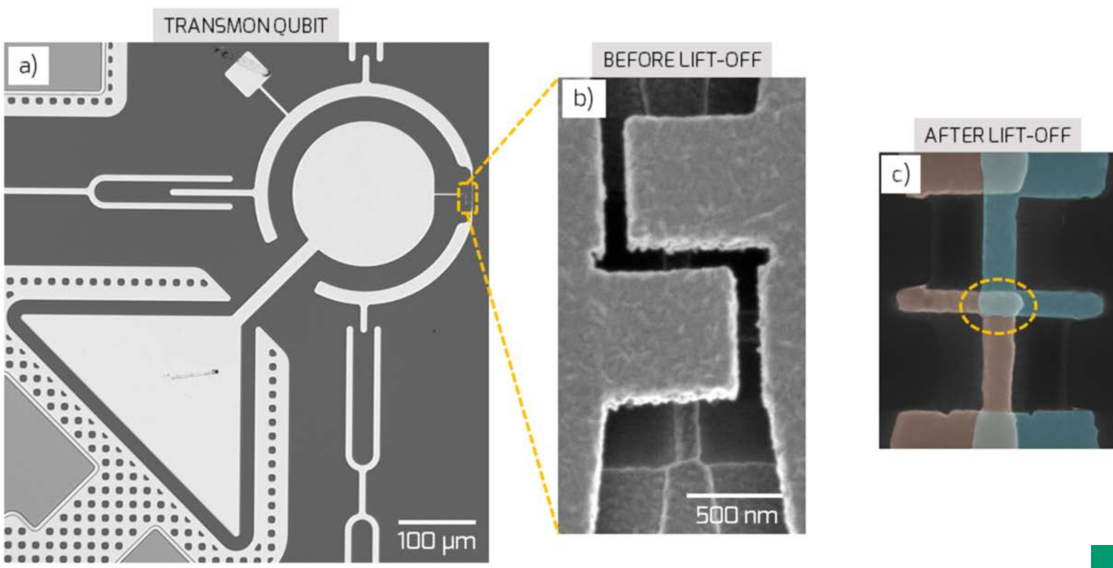
Research Highlight: Rigetti Computing

- Motivation: develop a scalable quantum computing platform for artificial intelligence and computational chemistry
- Technique: fabrication of Josephson junctions, comprised of aluminum electrodes separated by a thin insulating barrier



a) Fabricated transmon qubit. b) Bilayer e-beam resist stack after JEOL 6300FS e-beam patterning and double-angle aluminum evaporation. c) False color image of the Josephson junction at the end of the fabrication process.

Rigetti Computing is a leading quantum computing start-up which recently raised $64M in Series A and B funding. The company was founded in 2013 and has currently about 50 employees. http://www.rigetti.com

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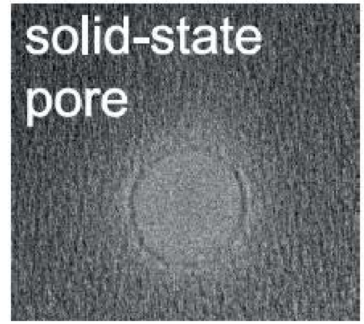
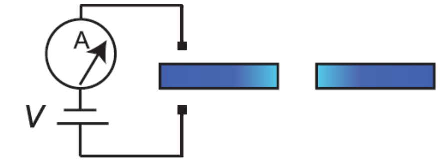
Research Highlight: Two Pore Guys

- Motivation: single molecule detection platform based solid-state nanopore technology
- Technique: fabrication of nanopore using e-beam lithography



Single-molecule sensing with a nanopore device.



Voltage V applied across a single 27nm diameter nanopore, while measuring current through the pore

Two Pore Guys Announces Global Licensing Agreement With Monsanto for Its Rapid Detection Technology Platform

Announcement marks 2PG's first agriculture agreement; Initial assays will target biomolecule detection in crops, pests and pathogens to improve lab and in-field testing efficiencies

Two Pore Guys makes a digital, hand-held, testing platforms. Closed a $24.5 million Series A round in April 2017. The company was founded in 2011 and has currently about 50 employees.
http://twoporeguys.com

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Education and Outreach Activities

Nanoscience Summer Institute for Middle School Teachers (SIMST)

- SIMST: 3 day workshop
- Emphasis on hands-on and experiments like ferrofluid, self-assembly, and dye-sensitized solar cells
- Follow-up workshops and support throughout the year
- Plans:
  - extend program with an Research Experience for Teachers (RET)

Partnerships: Cal State University - East Bay

- **Fall 2015:** Prof. Ryan Smith joins proposal for NNCI, CSUEB's first field trip to nanofacilities
- **Fall 2016:** Prof. James Tandon visits with computer science class
- **Spring 2017:** Prof. Smith brings class to perform fabrication & characterization methods in SNF. Highlighted in [Stanford Report]
- **Summer 2017:** Prof. Smith prepares educational journal article for submission with Stanford
- **Fall 2017:** Prof. Smith is onboarding as a user to utilize more instruments

Professor Ryan Smith and his students are gowned up and prepared to enter the Stanford Nanofabrication Facility.

Staff member Uli Thumser performs an oxide etch on photovoltaic cells samples students brought to Stanford Nanofabrication Facility (SNF).

Developing similar partnership with Cañada College

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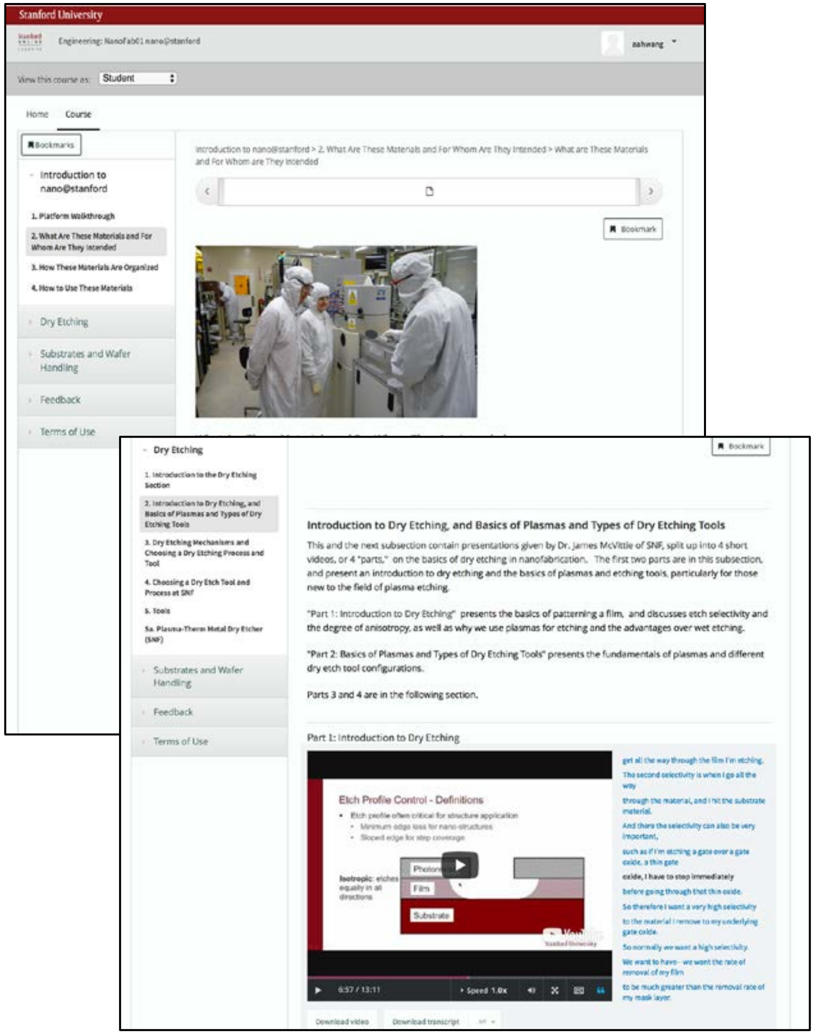
Researcher Education

- Motivation
  - educational practices that will help researchers become knowledgeable and proficient users of the facilities
- Developed pilot modules on an edX-based platform
  - plasma etching and wafer handling
  - Under development: lithography and light
  - microscopyontent development includes resource research, media production, and lab-specific training
- Coordinating to utilize network resources for content development and deployment



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Network Activities

- Nanodays
- Workshops
- Webinars
- Teacher Development
- User Education & Training
- …

How the National Nanotechnology Coordinated Infrastructure Nodes Support Environmental Research: Examples from the Field.

Thursday July 27th 2017 1:00-2:00 pm (Eastern)

Speakers:

Dr. Bruce Clemens (Walter B. Reinhold Professor in the School of Engineering and Professor of Photon Science and, by courtesy, of Applied Physics, Stanford University)

Dr. Clemens studies growth and structure of thin film, interface and nanostructured materials for catalytic, electronic and photovoltaic applications. He and his group investigate phase transitions and kinetics in nanostructured materials, and perform nanoparticle engineering for hydrogen storage and catalysis. Recently he and his collaborators have developed nano-portals for efficient injection of hydrogen into storage media, dual-phase nanoparticles for catalysis, amorphous metal electrodes for semiconductor devices, and a lift-off process for forming free-standing, single-crystal films of compound semiconductors.

Dr. Michael Hochella (University Distinguished Professor, Geosciences, Virginia Tech).

Michael Hochella is University Distinguished Professor at Virginia Tech, concentrating on the area of nanogeoscience. His research interests include nanoscience and mineral surface geochemistry, and elucidating the role that these play in earth science, with particular interest in environmental issues. In addition to this, Dr. Hochella's team work on mineral-microbe interactions from both a geochemical and biochemical perspective and characterize aqueous partitioning reactions at oxide and silicate surfaces.

Moderator:

Dr. Larry Goldberg (Senior Engineering Advisor in the Division of Electrical, Communications and Cyber Systems, Directorate for Engineering, National Science Foundation).

Dr. Goldberg is lead program officer and guided the competition for the National Nanotechnology Coordinated Infrastructure (NNCI). He has coordinated joint activities on nanoelectronics with the Semiconductor Research Corporation, conducted under NSF's emphasis area on Nanoscale Science and Engineering. He led federal agency funding for the 2012 National Academies study on Optics and Photonics: Essential Technologies for Our Nation. He serves as NSF member of the interagency Wireless Spectrum Research and Development Senior Steering Group, and represents the Engineering Directorate on the NSF program Enhancing Access to the Radio Spectrum (EARS). He also coordinates the Major Research Instrumentation (MRI) program for the Engineering Directorate.

Network Activity Highlight: 2017 NNCI ALD/MOCVD Symposium

- Stanford and Harvard co-hosted symposium in April, 2017 at Stanford University.
- build networks between university shared labs
- Technical & research talks
- Participation:
  - 13 Universities, including
  - 9 NNCI sites
  - 100 researchers, includin
  - 46 industry participants

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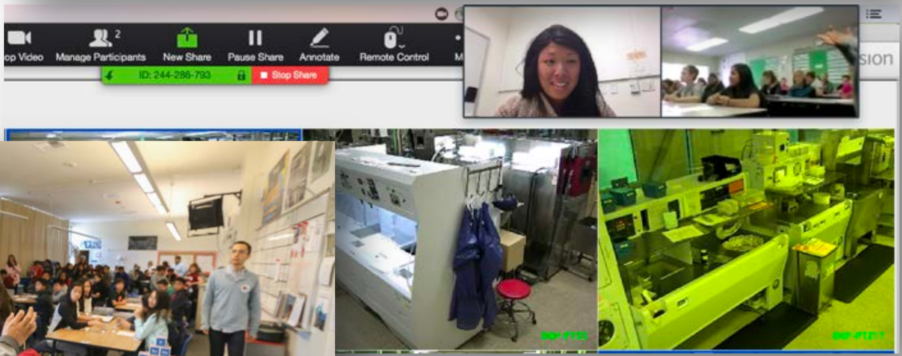
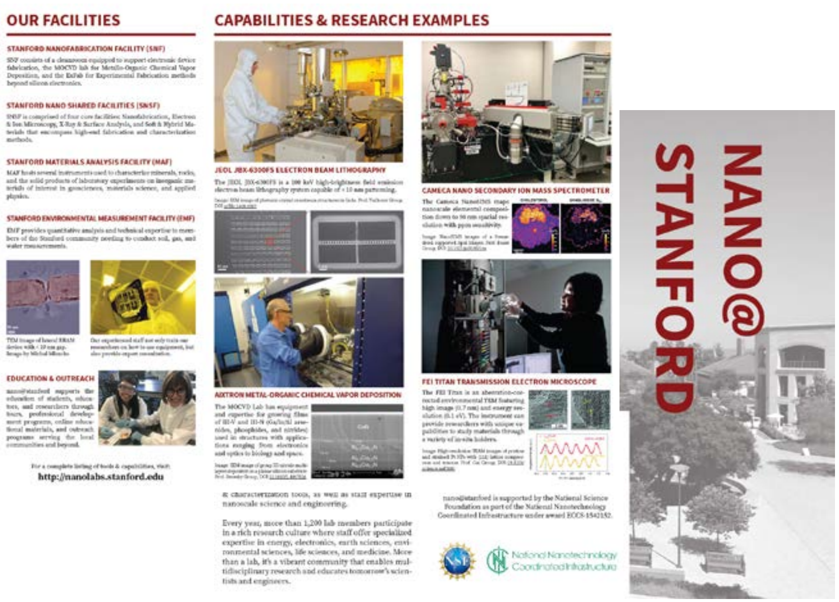
National Nanotechnology Day – October 9th, 2017

- 100 billion nanometer race
- Remote tours
- Classroom visits with hands-on activities
  - Staff and students visited local middle schools, utilizing SIMST teacher connection



Panel discussion topic: Future Research Directions

- In-situ or in-operando techniques
- Integration of soft, bio and hard materials and approaches
  - Attract users from new communities
  - Integrate users across facilities
  - Brochure
    - Focus on unique capabilities for non-traditional users
- Cross-platform, multi-technique data blending



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Thank you!

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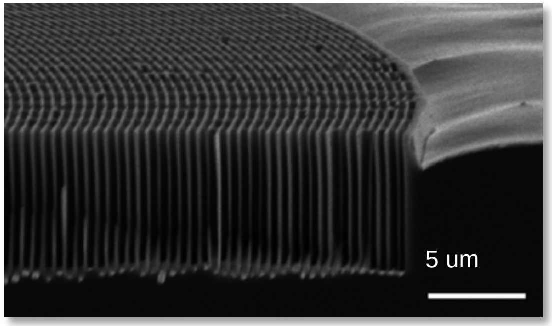
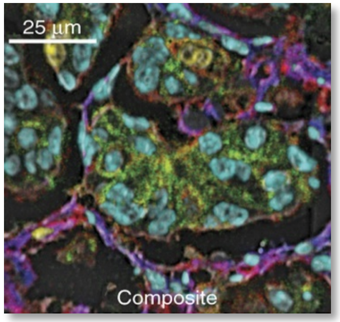
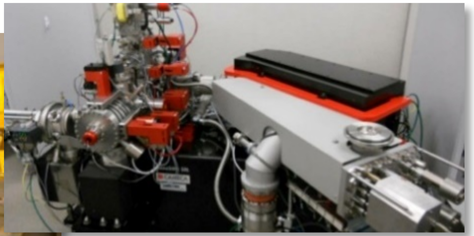
~1,200 annual users take advantage of a comprehensive array of advanced nanofabrication and nanocharacterization tools available within the Stanford Nano Shared Facilities (SNSF), the Stanford Nanofabrication Facility (SNF), the Mineral Analysis Facility (MAF), and the Environmental Measurement Facility (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

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