Cornell Nanoscale Science and Technology Facility (CNF)

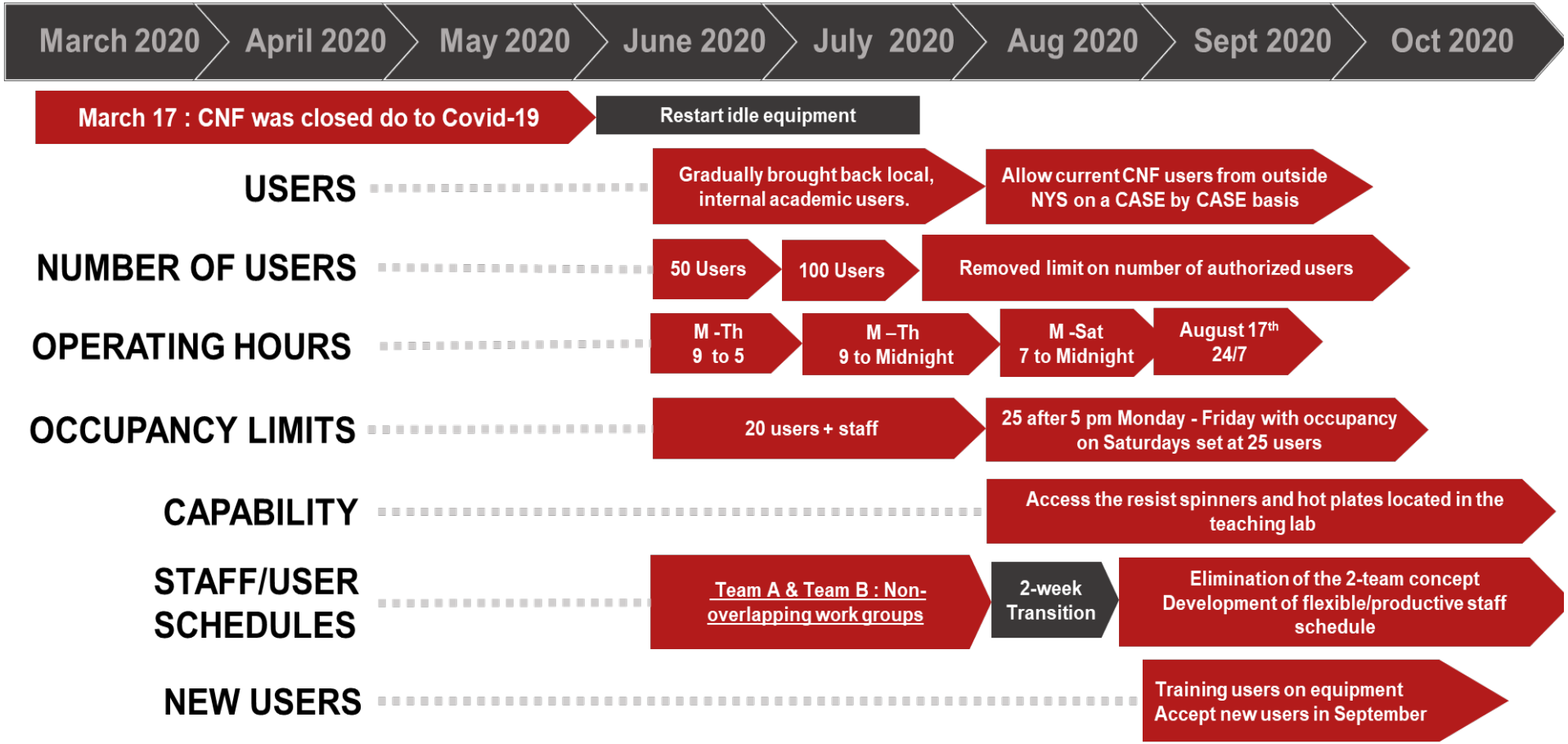
Cornell NanoScale Science & Technology Facility

NNCI ANNUAL CONFERENCE
October 26-27, 2020

Chris Ober, Lester B. Knight Director
Claudia Fischbach-Teschl Associate Director
Ron Olson, Director of Operations
Lynn Rathbun, Laboratory Manager

FACILITY OPERATIONS

Current Status



PLANS AND NEW CAPABILITIES

New Associate Director

Prof. Claudia Fischbach-Teschl, Co-PI, Assoc. Director (focus on life sciences)

New Partnership

- Morgan State University (HBCU graduating largest number of electrical engineers)
- Summer REU
- Infrastructure guidance

Expanded 4-H Outreach

- The 4 NNCI land grant schools (Nebraska, Montana State, Virginia Tech, Cornell) collaborating on 4-H

New Facilities

1. **Multiscale 3D Fabrication Facility**
   - Focused on life sciences and heterointegration
   - Nanoscribe** and 10 3D printers
2. **3D Visualization Facility**
   - Confocal and multiphoton microscopes
   - Super-resolution microscopes
   - X-ray CT
   - Ultrasound, and bioluminescence/ fluorescence macro imaging systems
   - nm to mm size range

Research Communities

- Rules of Life
- Quantum Leap (AccelNet)
- Nano-Enabled IoT

Startup Partnership

PRAXIS: Engineering and Physical Sciences Business Incubator, co-located in Duffield Hall – 5 new startups next door

New activities are in line with our strategic plan

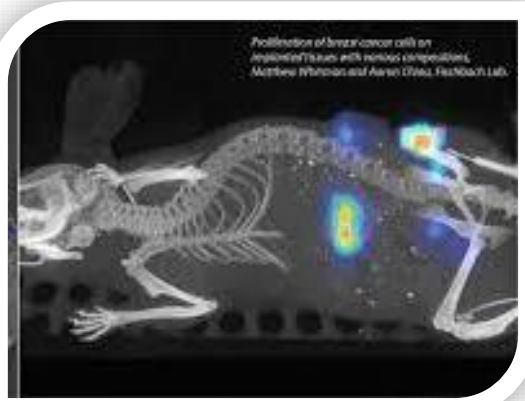
PLANS AND NEW CAPABILITIES

New 3D Printing Capability in the Multiscale 3D Fabrication Facility (M3FF)

- By partnering with existing Cornell resources we will be able to deploy this capability now covering length scales from nm to mm
- CNF will build on its new Nanoscribe 3D Lithography System and existing 3D printers by absorbing additional printers to create a 3D printing facility
- CNF staff will be trained in tool use and repair

New 3D Visualization Facility (3VF)

- New imaging capabilities available within the **Cornell Institute for Biotechnology** will be linked to CNF/NNCI for non-destructive imaging of 3D structures
- Tools include confocal and multiphoton microscopes, super-resolution microscopes, X-ray CT, ultrasound, and bioluminescence/ fluorescence macro imaging systems for nm to mm size range



NEW EQUIPMENT

Highlights

- **Nanoscribe Photonic Professional GT 2 3D Laser Lithography system**
  - Supports our efforts in Biotechnology and new emerging materials and chemistry technologies
- **Plasma-Therm Atomic Layer Etch (ALE) system**
  - Supports our strategic focus in 2D Materials
- **AJA Orion 5 Sputtering system**
  - Supports our efforts in 2D materials and Quantum Information Systems
- **HDP-CVD System from Plasma-Therm**
  - Supports efforts in 2D materials and Heterointegration

NNCI Site @ Stanford
(nano@stanford)


Debbie Senesky
Professor of Aeronautics and Astronautics

List of Participants

PI:
Debbie Senesky, Associate Professor of Aeronautics and Astronautics

Co-PIs:

- **Bruce Clemens**, Professor of Materials Science & Engineering, Director of Stanford Nano Shared Facilities (SNSF)
- **Kate Maher**, Associate Professor of Earth System Science
- **Nick Melosh**, Associate Professor of Materials Science & Engineering, Director of Stanford Nanofabrication Facility (SNF)

Finance Manager:

- **Ai Tan**, Finance & Administration Manager of Stanford Nanofabrication Facility (SNF)

Key Participants:

- **Marcin Walkiewicz,** Senior R&D Engineer of Stanford Nano Shared Facilities (SNSF)
- **Tobi Beetz**, Associate Director of Stanford Nano Shared Facilities (SNSF)
- **Mary Tang**, Associate Director of Stanford Nanofabrication Facility (SNF)
- **Angela Hwang**, Director of Education & Outreach Programs (NNCI)

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Impact: Summary Highlights (Years 1-5)

Served researchers:
2,094 internal
754 industry
136 other academic
232 government & non-profit

~1,500 publications 

99% of users said they would recommend nano@stanford to a colleague (FY19)

217 companies
34 universities

272 person-years of equipment use

Over 6,000 public participants in E&O programs

Produced 40 videos with over 73,000 views

Over 2,000 learners accessed courses

Trained 57 teachers (~40% from Title I schools), impacting 2,000 students 

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Facilities and Tools Highlight (Installation Underway)

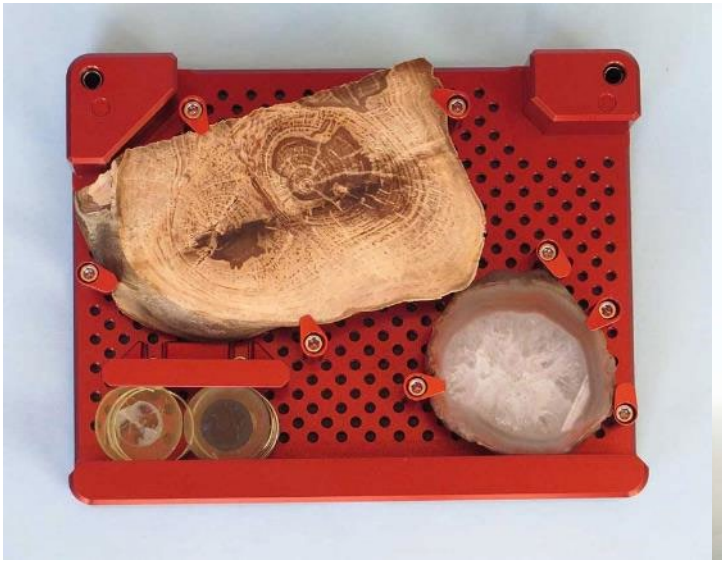
Stanford Isotope and Geochemical Measurement & Analysis (SIGMA) Facility

Agilent 8900 Triple Quadrupole ICP-MS

- Determination of elemental concentrations in solutions (sub-ppb / ppt)
- Characterization of nanoparticle size distributions in food, environmental and engineered materials.

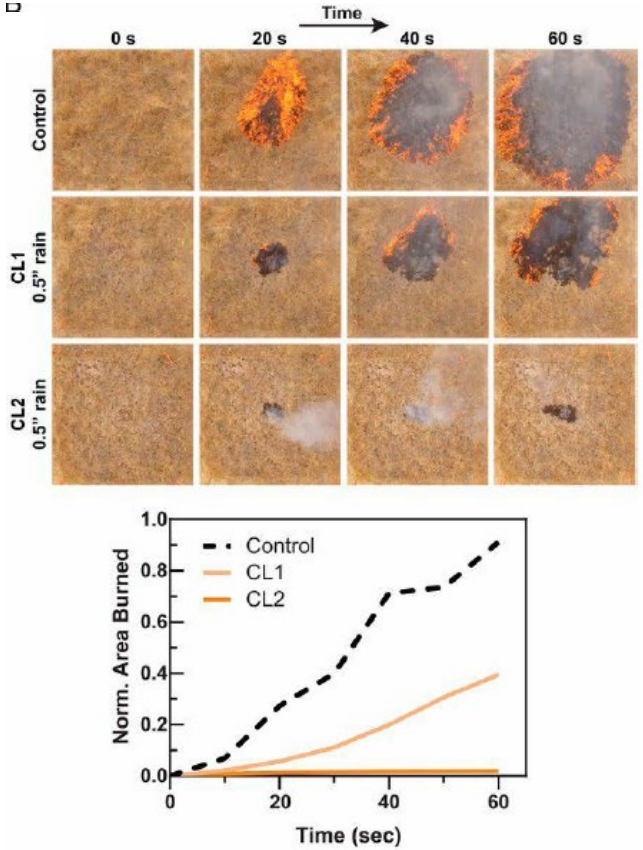
Applied Spectra RESOlution Excimer laser

- Sample introduction system for QQQ-ICP-MS
- In-situ element mapping of trace elements in natural and engineered materials
  - Accommodates irregular sample geometries
- Compositional depth profiling

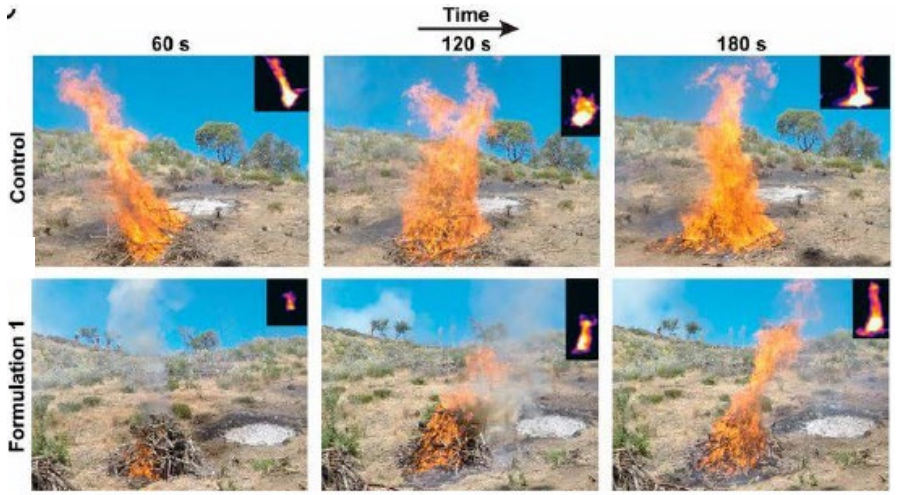


Research Highlights

Wildfire prevention through prophylactic treatment of high-risk landscapes using viscoelastic retardant fluids

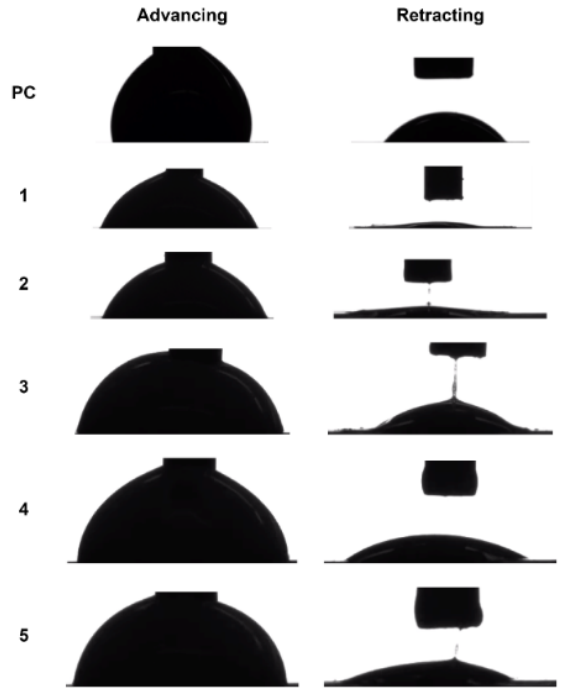


Above: Controlled burn of unmowed grass either untreated, or treated with 2 different levels of retardant.



Above: Pilot-scale burns of chamise piles, treated or untreated, with infrared (IR) image overlays.

Profs. Apple, Criddle (Stanford), and Acosta (CalPoly)
PNAS (2019) doi:10.1073/pnas.1907855116
nano@stanford Tools: TGA, Contact Angle Goniometer
Now a start up: https://www.ladera.tech/



Above: Contact angle goniometer measurements (nano@stanford) of droplet spreading. Each polymer formulation showed better wetting than the Phos-Check (PC) control.

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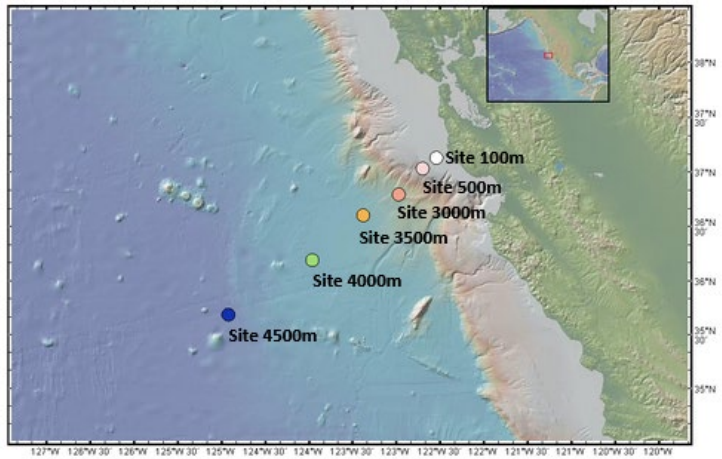
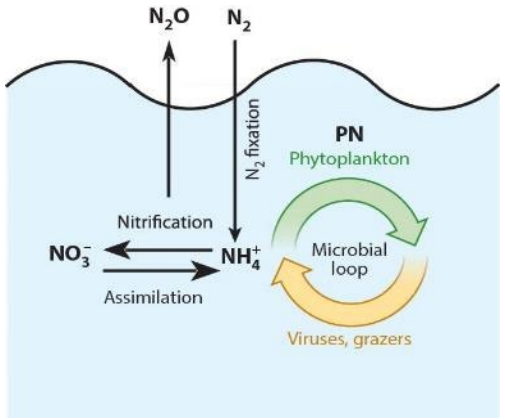
Ladera TECH

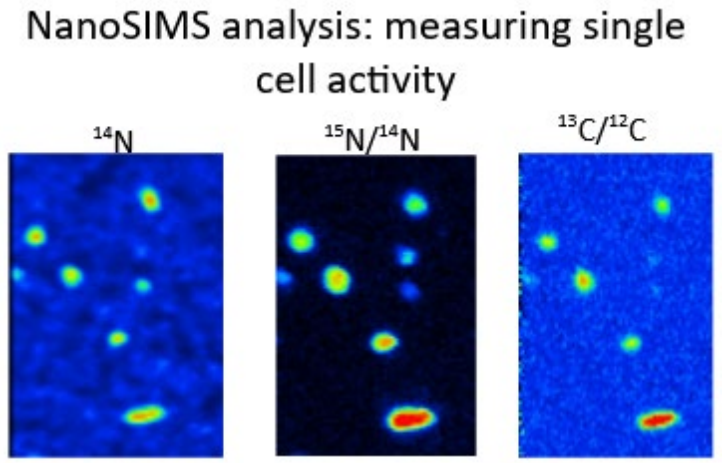
Research Highlights

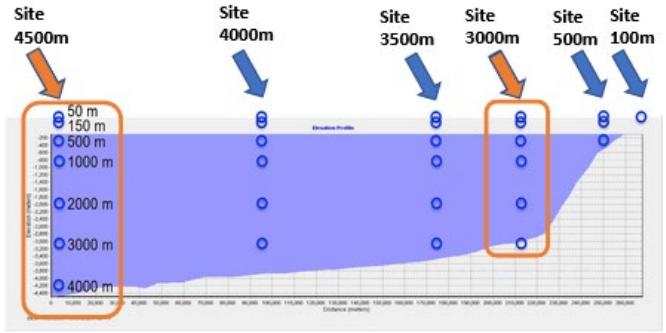
Quantifying nitrogen assimilation in the deep ocean

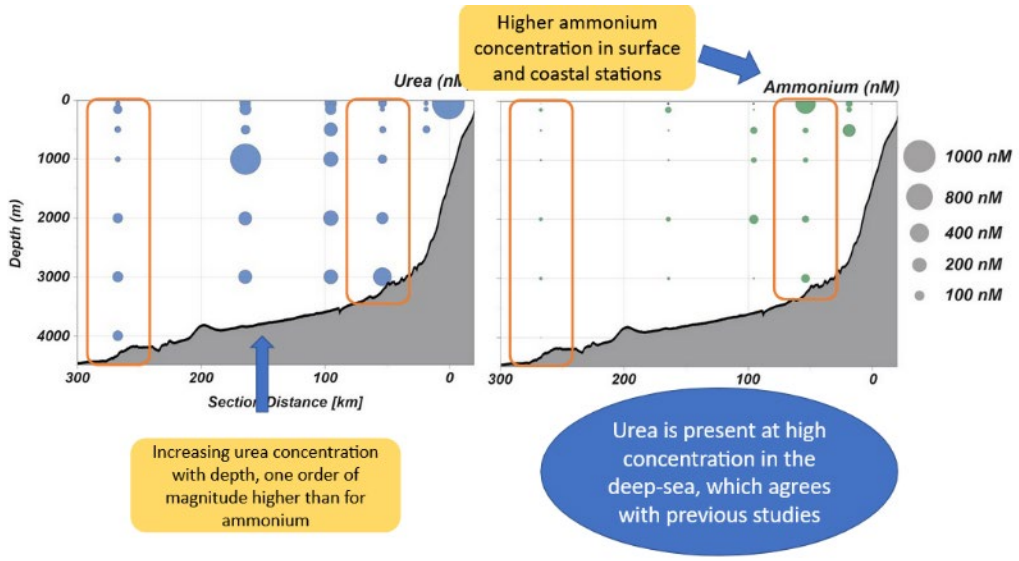




Modified from Zehr and Kudela, 2011







Nestor Arandia-Gorostidi, Alma E. Parada, Alexandra R. Bausch, Anne E. Dekas (in preparation)

Earth System Science, Stanford University
Simons Foundation

nano@stanford Tools: NanoSIMS

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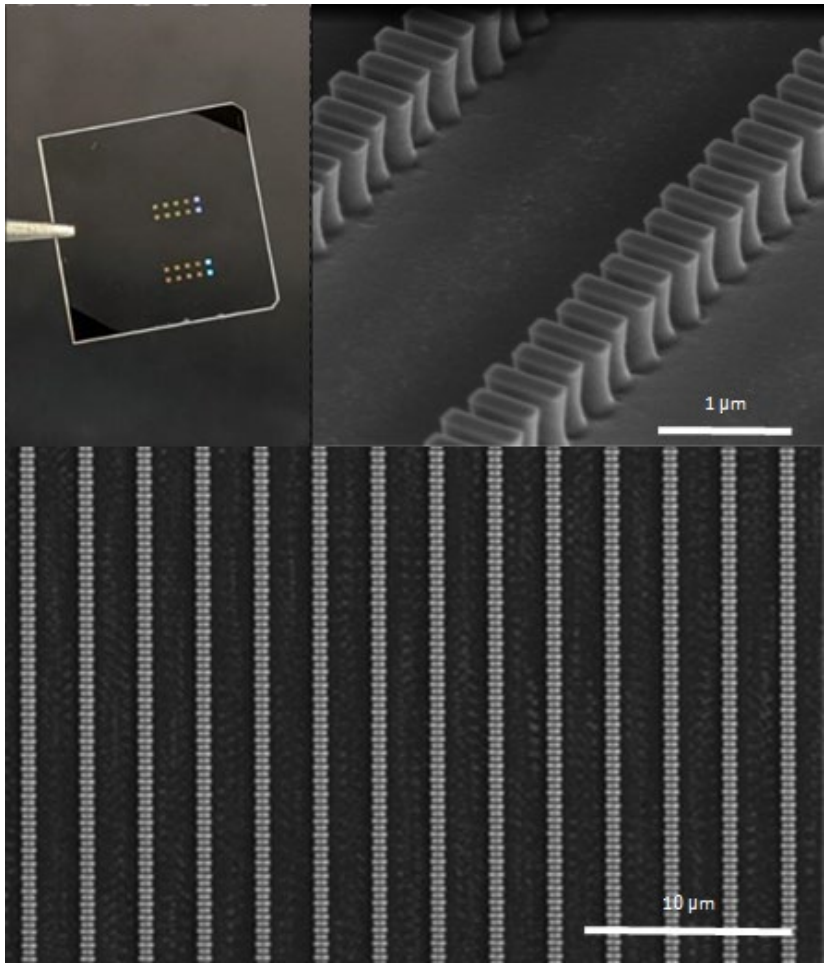
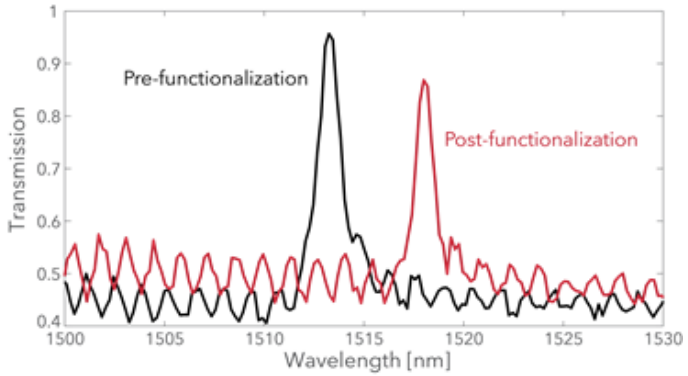
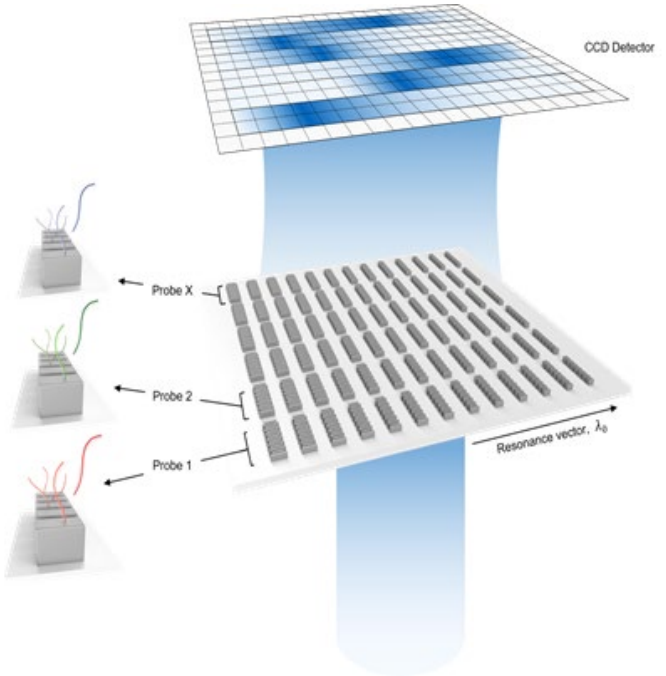
Rapid diagnostics with slow light using silicon photonics

- Silicon nanoantennas confine light and amplify the local electric field, resulting in ultra-high sensitivity for rapid, accurate diagnostics
- The precise asymmetry of the nanoantennas “slows” transmitted light, resulting in sharp resonances
- When the silicon is functionalized to bind with specific nucleic acids or antibodies (e.g. for SARS-CoV-2 diagnostics), the sharp resonance shifts
- In the future, isolated antennas can be functionalized separately for highly multiplexed diagnostics on a scalable silicon-based platform







Prof. Jennifer A. Dionne (Stanford)
work in progress and Nat. Nano 2020
(doi: 10.1038/s41565-020-0754-x)
nano@stanford Tools: JEOL JBX-6300FS E-beam Lithography System

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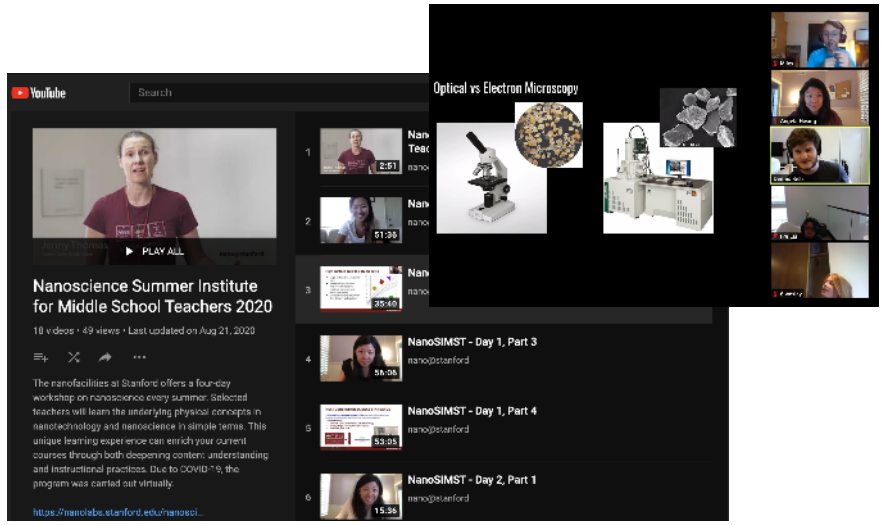
Education and Outreach

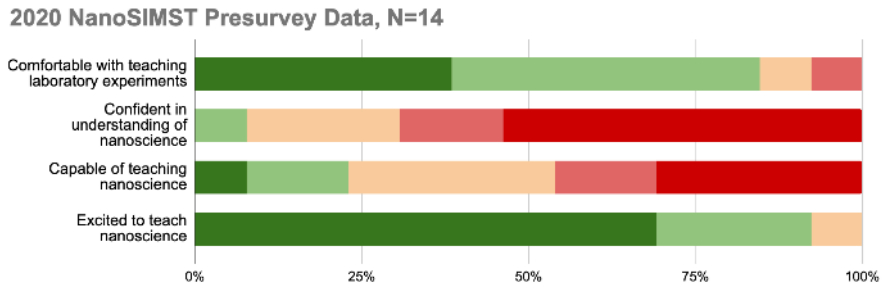
Nanoscience Summer Institute for Middle School Teachers held virtually

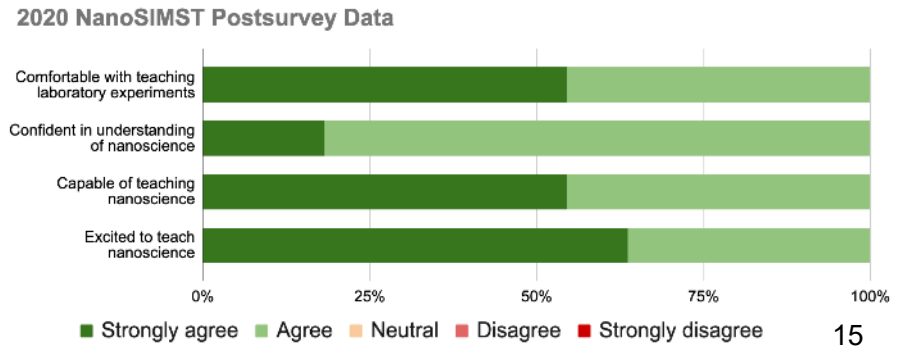
- Data shows learning is not impacted by virtual environment
- GT held parallel program online, utilized UCSD remote SEM & Cornell's Nanooze
- 7 of the 14 teachers come from Title I schools
- *"...given all the limitations of doing this online, I think it was really well done." " the presentation was wonderful in a circumstance never experienced before. I appreciate the ingenuity."*

Increased efforts for technical learning

- edX enrollment and video development & viewing
- Continue expanding the technical education library
- Involve other sites in joint content development







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Education and Outreach

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Bay Area SCIENCE FESTIVAL

10 Year Anniversary
OCTOBER 21–25, 2020

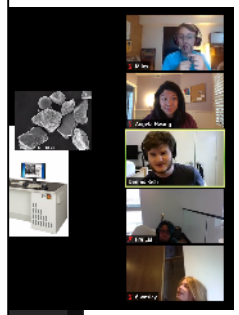
Wednesday 1:00 pm 2:00 pm PDT

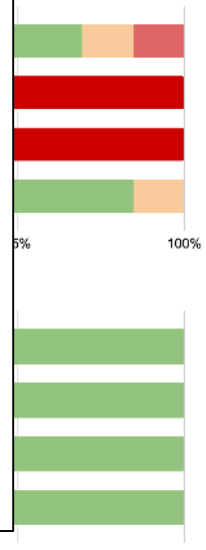
☆ Add | GCal | ICS | Details

nano@stanford Remote Tours

Summary: Virtual visit of nano@stanford's research equipment, facilities and researchers working on the latest micro and nanotechnology.

Type: Explorer Tour | Topic: Technology | Target Audience: 3rd - 6th Grade, Teens, Adults, Families





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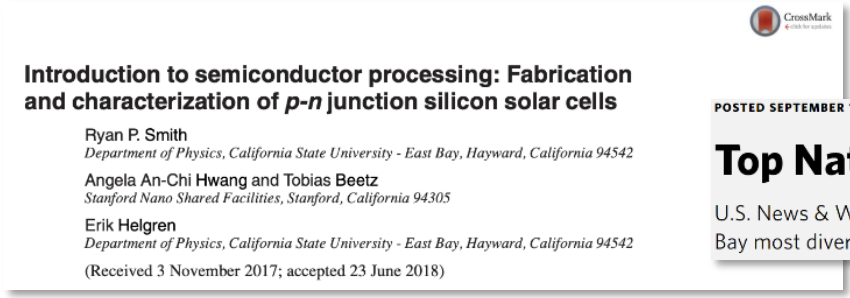
Academic Partnerships

Example: Cal State East Bay*

- Started NNCI Year 1 with phone conversation
- Small tours, growing larger to include classes
- Class work being performed at nano@stanford
- Collaborative education paper in 2018

CAL STATE EAST BAY



Introduction to semiconductor processing: Fabrication and characterization of *p-n* junction silicon solar cells

Ryan P. Smith
Department of Physics, California State University - East Bay, Hayward, California 94542
Angela An-Chi Hwang and Tobias Beetz
Stanford Nano Shared Facilities, Stanford, California 94305
Erik Helgren
Department of Physics, California State University - East Bay, Hayward, California 94542

(Received 3 November 2017; accepted 23 June 2018)

POSTED SEPTEMBER 14, 2017

Top National Ranking

U.S. News & World Report scores Cal State East Bay most diverse university in the country

Community College Internships

- Motivation - give community college students hands on experience, began early 2019
- Progress - supported 4 students from Foothill College, Cañada College*, College of San Mateo*
- Future Work - Continue supporting 2 interns per year, expand to support more MSIs (Ohlone*, SJSU*)
- Track career of interns - all went to 4 year colleges!

* Minority serving institutions (MSIs)

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NNCI Cooperative Network Activities

Staff Exchange Program

- Support local staff for travel to another NNCI site to learn or collaborate on a project

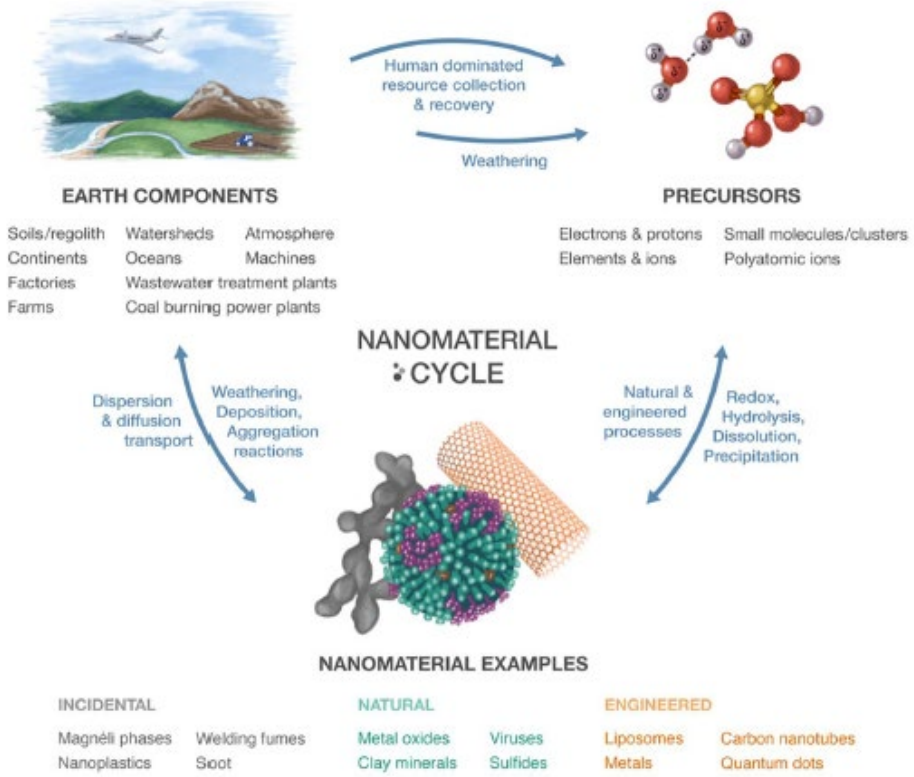
Research Communities

- Actively participate

Research Community	Point of Contact	
Quantum Leap	Senesky (& Vuckovic)	hold workshops w/ Stanford's Qfarm; explore emerging tools and fabrication processes supporting quantum research
Rules of life	Melosh	connect NSF's Plant Cell Atlas community with NNCI resources
NanoEarth Systems	Maher	hold annual workshops bringing nanoscience to earth and environmental science; host REUs

Toolkit for Assessing Impacts of NNCI Sites

- Partnership with SENIC and RTNN to track NNCI publications in Web of Science



nano@stanford will co-lead activities with MONT, nanoEarth, and NNCI-SW (Image credit: Hochella et al., Science, 2019.)

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Thank you!

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.

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Southeastern Nanotechnology Infrastructure Corridor (SENIC)

NNCI: Southeastern Nanotechnology Infrastructure Corridor (SENIC)

5th NNCI Annual Conference

SENIC Southeastern Nanotechnology Infrastructure Corridor

National Coordin

JSNN
Joint School of Nanoscience and Nanoengineering
North Carolina Agricultural and Technical State University
University of North Carolina at Greensboro

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Georgia Tech Institute for Electronics and Nanotechnology

SENIC: 3 Universities – 2 Locations – 1 Site

Partnership of two major & modern nanotechnology centers in the southeastern US:

- **Institute for Electronics and Nanotechnology (IEN),** an Interdisciplinary Research Institute at the Georgia Institute of Technology (GT)
- **Joint School of Nanoscience and Nanoengineering (JSNN)**, an academic collaboration between North Carolina A&T State University (NCA&T) and University of North Carolina, Greensboro (UNCG)

GT-IEN Marcus Nanotechnology Building

JSNN Building

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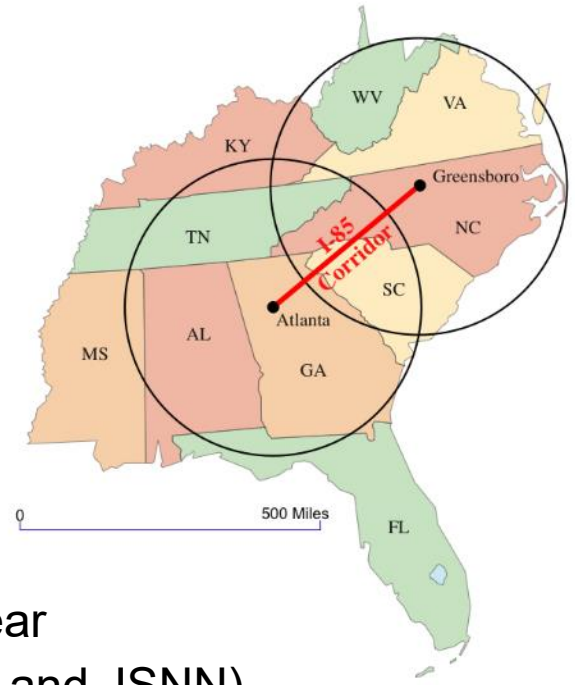
SENIC Southeastern Nanotechnology Infrastructure Corridor

SENIC Vision & Strategic Goals (Years 6-10)

Vision Statement

*The SENIC vision is to be a **premier nano-fabrication and nano-characterization resource to southeastern US user communities** from academia, small and large companies, and government organizations, **providing tools, staff expertise, E&O activities, as well as SEI of nanotechnology programs**.*



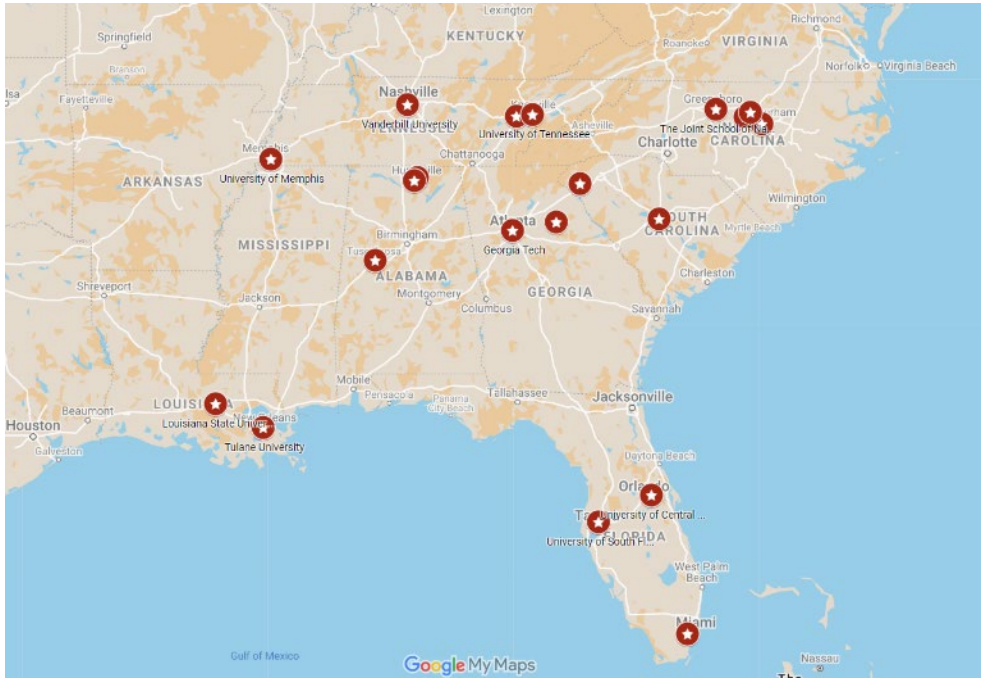
Strategic Goals

1. Develop and Serve Diverse User Base
   - Increase number of external users by 10% per year
2. Develop Strong Synergies between Partners (GT IEN and JSNN)
   - User Experience, Joint User Outreach, E&O, Exchanges, Meetings
3. Expanding Capabilities based on Future Research Trends/Needs
   - Add and/or upgrade 10 tools (or unique capabilities) per year
4. Develop E&O and SEI Programs Targeting the SE
5. Assist NNCI Network in Becoming More Than the Sum of its Parts

SG1: Southeastern Nano Facility Network (SENFN)

Regional network of NSE user facilities located in southeastern US

- 2018 meeting @ GT, 2019 meeting @ ORNL
- 2020 virtual meeting (planned)
- 20 institutions from 8 states (including RTNN)
- Modeled after similar regional networks organized by MANTH and MINIC



Programs to serve diverse user base

- Awareness
  - Marketing, seminars/workshops, partnerships, targeted outreach
- Accessibility
  - Remote work services
- Affordability
  - Catalyst seed grant

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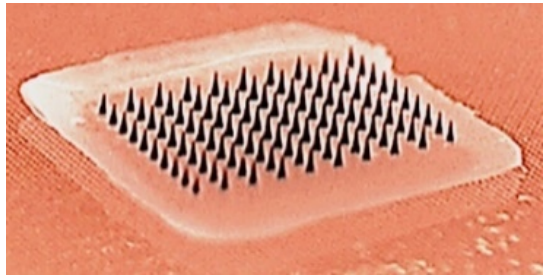
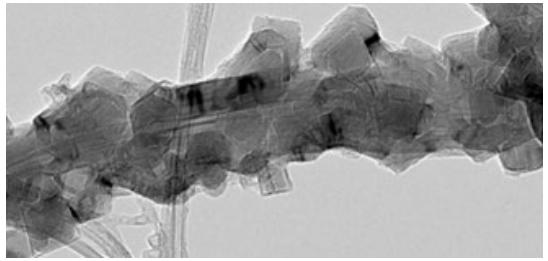
SG3: SENIC Capabilities based on Research Needs

Goals: - Add 10 tools/capabilities per year based on research needs
- Develop strong partnership with Oak Ridge National Lab

- **One-stop-shop** for fabrication and characterization needs
- Key areas where we see substantial growth:
  - Flexible & Wearable Electronics
  - Quantum Sciences
  - Next-Generation Electronics
  - Life Sciences, Medicine & Health
- Support NSF 10 Big Ideas and other grand challenges associated with e.g. security, energy, environment, health
- NNCI Research Communities
  - Nano-Enabled Internet-of-Things
  - Quantum Leap
  - Understanding the Rules of Life



Flu vaccine patch, Micron Biomedical



PET yarn with BN nanotubes, BNNano

Graphene energy harvester, U Arkansas-Fayetteville

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SG3: Enhanced Relationship with Oak Ridge NL

- Cross promotion of capabilities
- Joint seminars via video streaming
- Joint training efforts and staff exchanges
- Reciprocal tool backup
- Joint user/project support
- Joint user meeting

OAK RIDGE National Laboratory | CENTER FOR NANOPHASE MATERIALS SCIENCES

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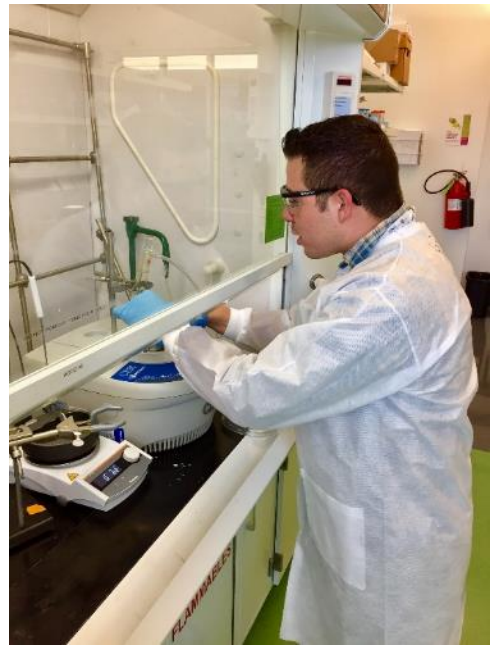
SG4: SENIC Technical College Student Interns

- **At JSNN (since 2015)**
  - 4-5 students/year from the Forsyth Technical Community College
  - 2 students/year from *NIH Maximizing Access to Research Careers (MARC)* Undergraduate Student Training in Academic Research Fellowship program
  - Promotion via program coordinator; formal application process with review & interview stages
- **New at GT-IEN**
  - Internship opportunities for Atlanta-area Technical Colleges: **Atlanta TC**, **Gwinnett TC**, Southern Crescent TC, Chattahoochee TC, West Georgia TC – Coweta Campus, Atlanta Metropolitan State College, Georgia State University – Clarkson Campus
  - Promotion via TC internship coordinator; formal application process for paid internship with review & interview stages



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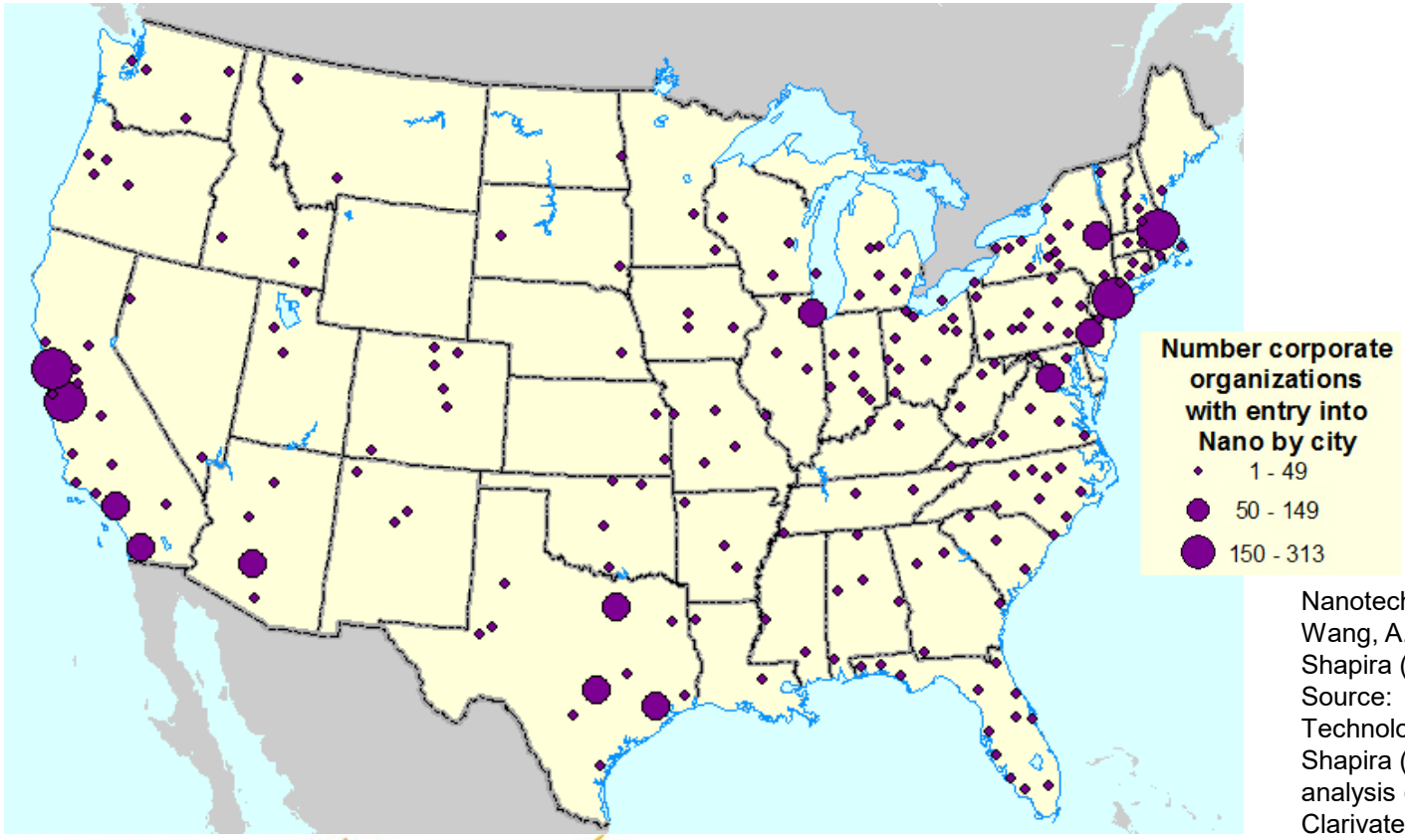
SG4: SENIC SEI Programs

Corporate entry into nanotechnology

Leading Continental US cities by number of corporate entries 2000-2019*



Nanotechnology search terms based on Z. Wang, A.L. Porter, S. Kwon, J. Youtie, P. Shapira (2019).
Source: A. Porter and N. Newman (Search Technology), R. Ward, J. Youtie, and P. Shapira (Georgia Institute of Technology), analysis of publications (April 2020) from Clarivate Web of Science and patents (PatStat, autumn 2019 edition).

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SG5: SENIC RET

Research Experiences for Teachers across the National Nanotechnology Coordinated Infrastructure

SENIC, SHyNE (Northwestern), MINIC (U MN), NNF (U NE, Lincoln)

- 5 educators at each site, 20 per year for 3 years
- High school and community/technical college faculty within commuting distance of each site
- Weekly virtual meetings – curriculum dev, research, industry guest speakers
- Attend NSTA to share experience/lessons with teachers at booth and presentation
- Provide webinar to Teaching Nano & Emerging Technologies Network

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Northwest Nanotechnology Infrastructure (NNI)

Northwest Nanotechnology Infrastructure (NNI)
New Initiatives for NNCI 2.0

University of Washington / Oregon State University
PI: Karl F. Böhringer
Annual Conference, October 26-27, 2020

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NNCI NORTHWEST NANOTECHNOLOGY INFRASTRUCTURE

NNI 2.0 Team – Facilities and Principal Focus Areas


Karl Böhringer


Maria Huffman


Lara Gamble


John Conley

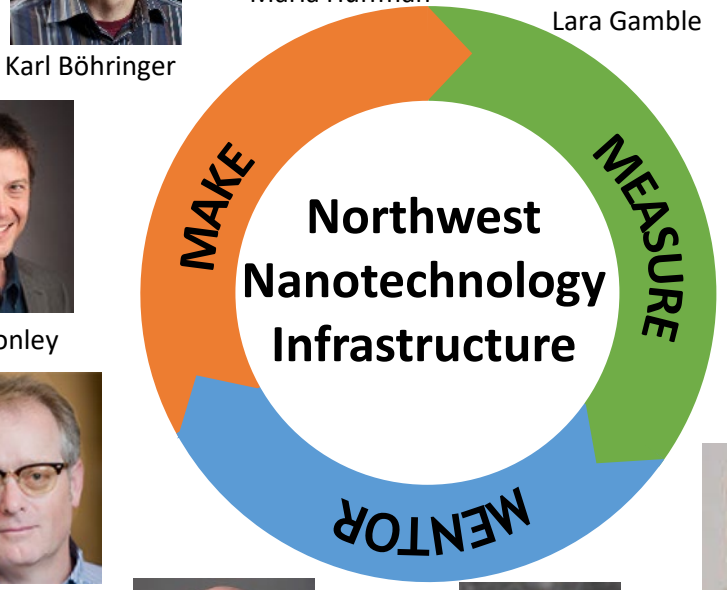

Greg Herman


Todd Miller


Liney Árnadóttir

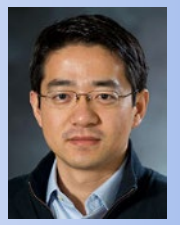

Daniel Ratner


Joe Baio



Integrated Photonics / Quantum


Kai-Mei Fu


Mo Li


Oksana Ostroverkhova

Energy Materials & Devices


Chih-hung Chang


Zhenxing Feng

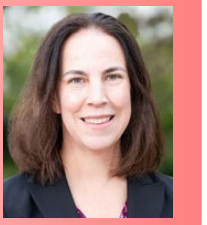

David Ginger


Daniel Schwartz

Bio-nano Interfaces


Joe Baio


Daniel Ratner


Lara Gamble

National Nanotechnology Coordinated Infrastructure

NNCI NORTHWEST NANOTECHNOLOGY INFRASTRUCTURE

NNI 2.0 Vision

The NNCI Northwest Nanotechnology Infrastructure acts as an engine for innovation and economic development by providing world-class nanotechnology infrastructure for a broad and diverse user base, paired with technical and educational leadership in photonic and quantum devices, advanced energy materials and devices, and bio-nano interfaces and systems.

NNI New Initiatives – Quantum Information Science

Updated Principal Focus Area: Photonic and Quantum Systems

- Northwest Quantum Corridor
  Vancouver-Seattle-Redmond-Richland-Portland-Eugene-Corvallis
  - Exchanges and seminars with quantum leaders in academia and industry
  - Synergy with UW QuantumX (depts.washington.edu/uwqis) and UW-PNNL-Microsoft Northwest Quantum Nexus (nwquantum.com)

- NNCI Research Community – Quantum Leap
  - Offering travel support and hosting events

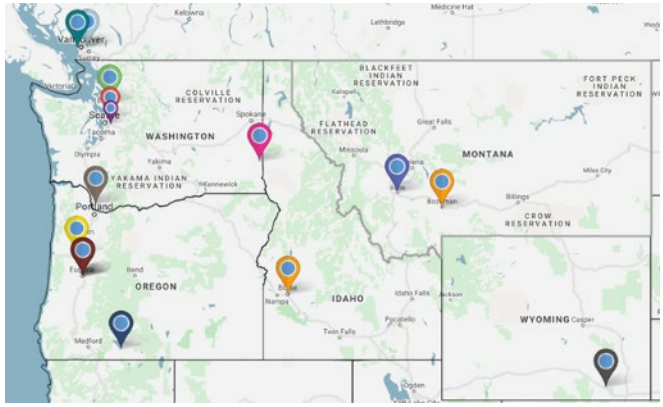
- Member of NSF AccelNet: Global Quantum Leap
  - Launched summer 2020, led by MiNiC

- NSF Research Traineeship – Accelerating Quantum-enabled Technologies

NNI New Initiatives – Expanding the User Base

NNCI Cooperative Network Activities

- Dedicated Business Outreach & Customer Development Manager at WNF
- Advanced prototyping cleanroom with low barrier of entry, adjacent to WNF – in planning stage
- Northwest Nanotechnology Laboratory Alliance (NWNLA)
  - Co-lead: Montana State University (MONT)
  - "Regional UGIM"
  - "Mini-sabbaticals" for staff
- Seed funds:
  - Open to new, first-time non-traditional users and underrepresented groups.
  - Applications accepted from high schools, community colleges, non-Research-1 universities, and small companies.



NNI New Initiatives – Novel Capabilities (Selection)

- Coming soon: Laser Laboratory (NSF MRI) at the Materials Synthesis & Characterization Facility (MaSC, OSU)
  - Laser/cryostat system, ultrafast (25 fs) high-power (1 mJ) pulses
  - Pump-probe microscopy and spectroscopy techniques
  - Study of emerging optical, magnetic, and electronic materials
  - nnci.oregonstate.edu/laser-laboratory
- New in 2020: Electron backscatter diffraction at the Molecular Analysis Facility (MAF, UW)
  - EBSD with energy dispersive spectroscopy (EDS) allows grain analysis of samples in the Apreo SEM sample chamber
- Planned at the Washington Nanofabrication Facility (WNF, UW)
  - JEOL JBX-6300FS electron beam lithography LINUX upgrade
  - Ion Beam Etcher: versatile tool, especially suited for novel quantum materials
  - Rapid prototyping cleanroom, lowering the barrier to nanofab (on hold due to COVID)

NNI New Initiatives – Tribal School Partnerships

Expand partnership with Chemawa Indian School

Educator in Residence Program: Studies have demonstrated that, when K-12 teachers take part in hands-on research experiences it significantly improves their students' achievement in science. Each summer a cohort of teachers from Chemawa will participate in NNCI research activities and develop education modules related to this experience.

Summer Experience in Science and Engineering for Youth: Each summer several Chemawa high school students will be invited to participate in NNCI research activities through the SESEY program at OSU.

National Nanotechnology Coordinated Infrastructure

NNCI NORTHWEST NANOTECHNOLOGY INFRASTRUCTURE

Nanotechnology Collaborative Infrastructure Southwest (NCI-SW)

Nanotechnology Collaborative Infrastructure Southwest

NCI Southwest

NNCI Annual Meeting

26-27 October 2020

Arizona State University

NAU Northern Arizona University

Trevor Thornton – Director

Jameson Wetmore - Deputy Director

Mariana Bertoni
Materials and Renewable Energy

William Graves
Free Electron Laser Spectroscopy

Paul Westerhoff
Environmental Nanoscience

Tom Sharp - Geological Nanoscience
Ray Tsui - Education Coordinator
Dragica Vasileska - Computation & Modeling

Inès Montaño - PI at NAU, Quantum Materials

Gabe Montaño – Nano-Bio Materials

Miguel Yacaman – Nanomaterials and Microscopy

Rio Salado College, A Maricopa Community College

NMU Gallup

Science Foundation Arizona, Innovation at Work

San Juan College

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New Initiatives for Years 6 - 10

NCI Southwest

Add ¡MIRA! at Northern Arizona University as an equal partner in the NCI-SW

¡MIRA! CENTER FOR MATERIALS INTERFACES IN RESEARCH & APPLICATIONS
NORTHERN ARIZONA UNIVERSITY

- Bring new programming initiatives to NCI-SW
- An existing network throughout the southwest of minoritized communities, institutions and partners
- Extensive experience in evaluation and data analysis of outreach interventions, particularly in diversity in STEM.
- World-class experts in soft, biological nanomaterials, advanced microscopy and quantum information

¡MIRA!

- Over 1500 Pier-reviewed Publications
- 53 Patents, 3 Start Up Companies
- Over 30 years combined experience in User Facility Operations and Management
- 50% Underrepresented Minority (URM)/Female faculty
- 100% URM/Female Leadership Team
- Diversity of leadership team provides role models for students

Inès Montaño:
NCI-SW NAU PI

Gabe Montaño:
NCI-SW NAU co-PI
¡MIRA! Chief Scientist and Founding Director

Miguel Jose Yacaman:
NCI-SW NAU co-PI

¡MIRA! means "Look!" in Spanish

New Initiatives for Years 6 - 10

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guel Jose
caman:
I-SW NAU co-PI

¡MIRA! means “Look!” in Spanish

New Initiatives for Years 6 - 10

New Advanced Electronics and Photonics (AEP) core facility

- State-of-the-art infrastructure
- 250,000 ft^2 total capacity
- 43,500 ft^2 cleanroom

A national resource for getting to pilot scale with new technologies

Home of the NCI-SW Solar Power Lab (part of QESST ERC)

- PV pilot line with tools for 156 mm silicon solar cell and module fabrication and characterization

Mariana Bertoni
School of ECEE
ASU

Small and Large Business Users/Tenants

VON ARDENNE

Vacuum systems

National Coorc

APPLIED MATERIALS make possible

CACTUS MATERIALS

Semiconductor material and packaging start-up

APPLIED MICROARRAYS

DNA and protein array start-up

EVG

Semiconductor equipment manufacturer

SWIFT COAT

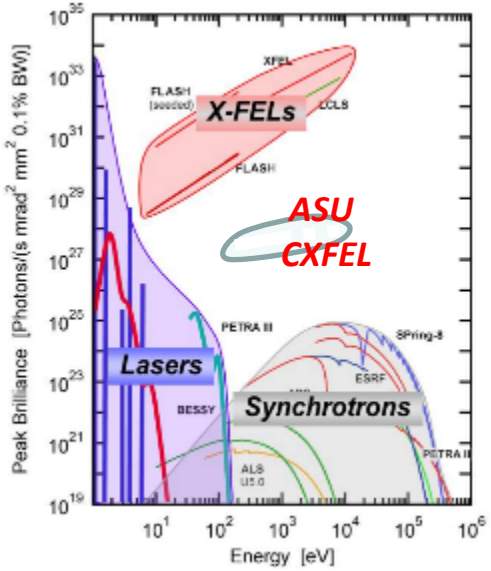
ASU start-up

New Initiatives for Years 6 - 10

NCI Southwest

Offer Compact X-Ray Free Electron Laser source to the NNCI community

- The ASU CXFEL is a <10 m long ~$20M instrument compared to a traditional ~ 1 mile long, ~$1B x-ray LINAC/synchrotron
- Funded by NSF Mid-scale RI1 and private philanthropy
- More beam time for the nano-community with applications including:
  - Quantum materials (fast photons control the ground state and non-equilibrium states of quantum systems)
  - Measuring quantum fluctuations in electronic systems (x-ray photon correlation spectroscopy)
  - Nano materials in extreme environments
- The CXFEL Phase 1 turns on in Q4 2020



Bill Graves
CXFEL Chief Scientist
Dept. of Physics, ASU

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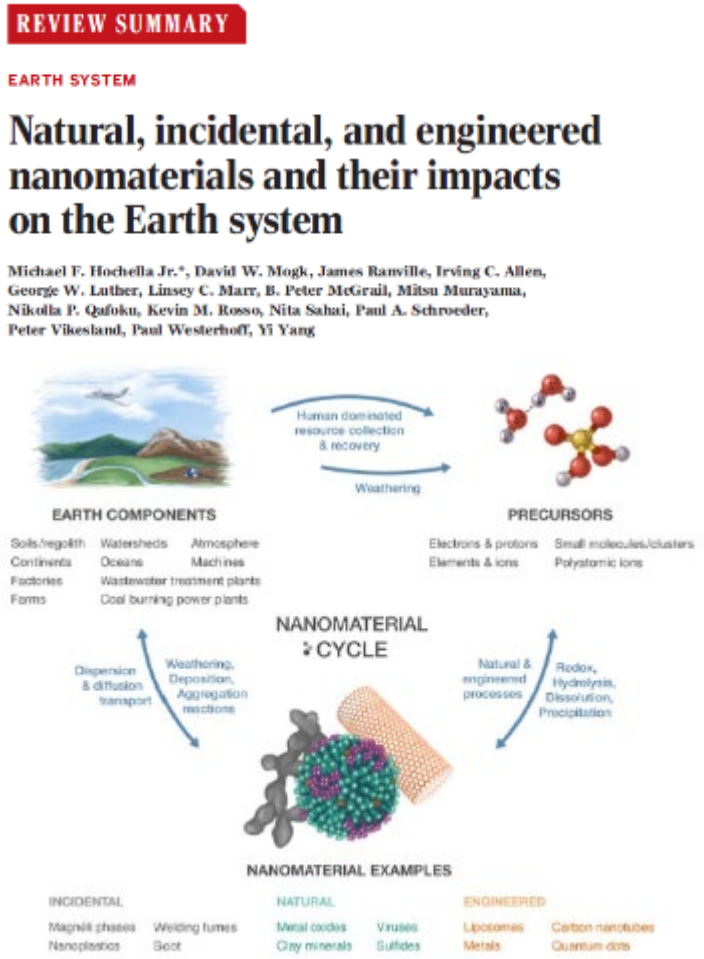
New Initiatives for Years 6 - 10

NCI Southwest

Establish Nano Earth Systems (Nano-ES) Research Community

- Building upon the NSF workshop and resulting Science paper, four NNCI sites will lead a Nano Earth Systems research community
  - NCI-SW, NanoEarth, MONT, Stanford
- Nano-ES bears upon national priorities
  - NNI Signature Initiative – *Water Sustainability through Nanotechnology*
  - NAE Grand Challenge - *Providing Access to Clean Water*
  - NSF 10 Big Ideas – *Growing Convergence Research*



National Nanotechnology Coordinated Infrastructure

NSF

Hochella et al., *Science*, vol. 363, pp. 1414 – 1423, 2019

New Initiatives for Years 6 - 10

NCI Southwest

NCI-SW will spearhead an SEI Research Community across NNCI

- Partner with SENIC, Texas Nanofabrication Facility, and RTNN
- Enhance the Science Outside the Lab program to include an SEI ambassador
  - Each student that gets the training will share what they've learned and facilitate events at their home institutions – increase reach and impact

- Integrate SEI into materials and training programs for K-12 students that can be distributed across the NNCI

  - Already created a 35-minute video on "Teaching the Social Implications of Nanotechnology to High School Students," for the NNI's "Teaching Nano & Emerging Technologies Webinar Series."

National Nanotechnology Coordinated Infrastructure

NSF

New Initiatives for Years 6 - 10

NCI Southwest

Establish southwest regional association of university nanotechnology laboratory managers

- Based on the successful model from the Minnesota MINIC site
- Annual workshop that rotates amongst the participating universities:
  - Arizona State University
  - Northern Arizona University
  - University of Arizona
  - University of New Mexico
  - University of Utah
- Establish best practices for managing cleanrooms and associated multi-user facilities, on-going challenges, and future opportunities

The ‘New’ NCI-SW

NCI Southwest

National Nanotechnology Coordinated Infrastructure

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The ‘New’ NCI-SW

NCI Southwest

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The ‘New’ NCI-SW

NCI Southwest

National Nanotechnology Coordinated Infrastructure

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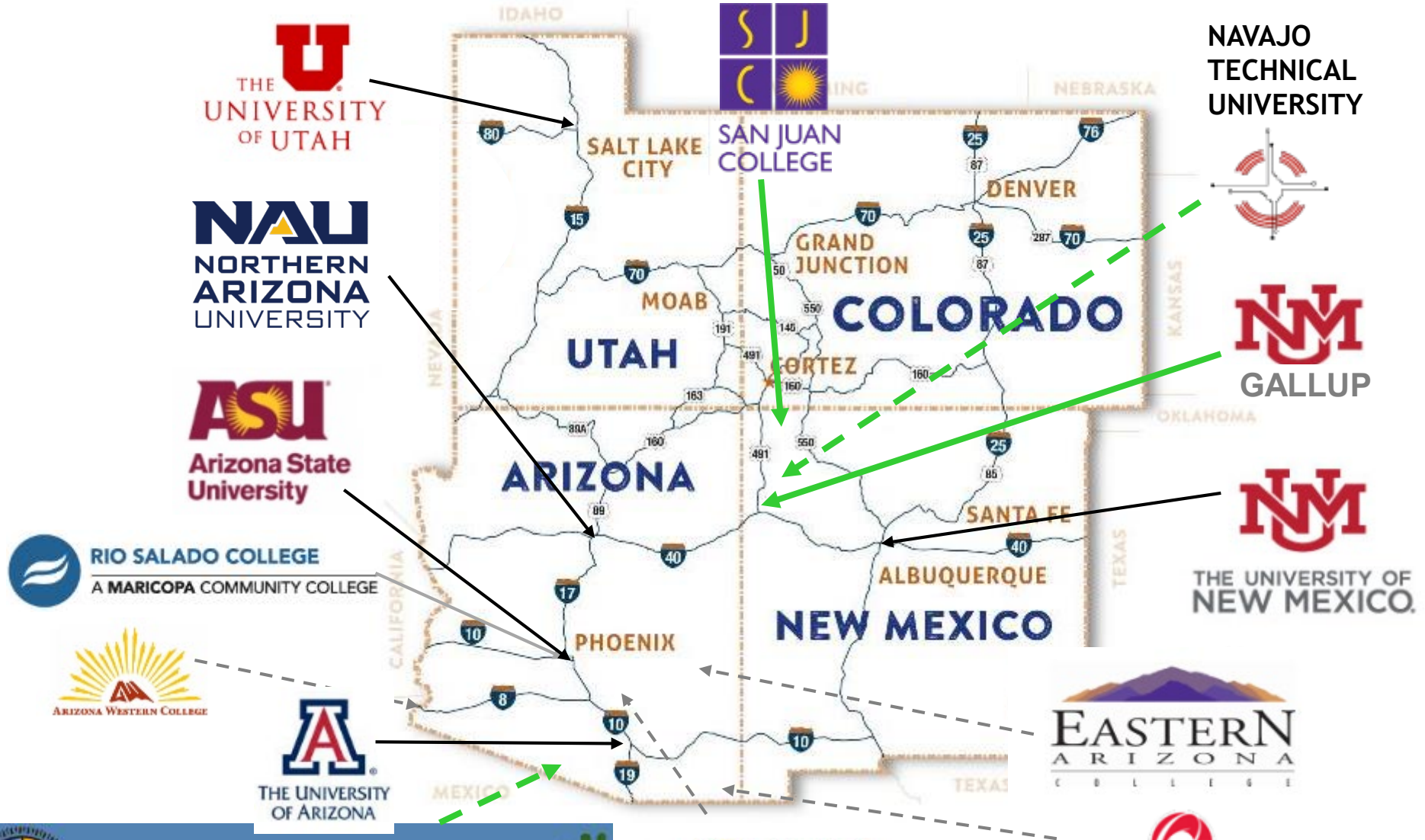
The 'New' NCI-SW

NCI Southwest

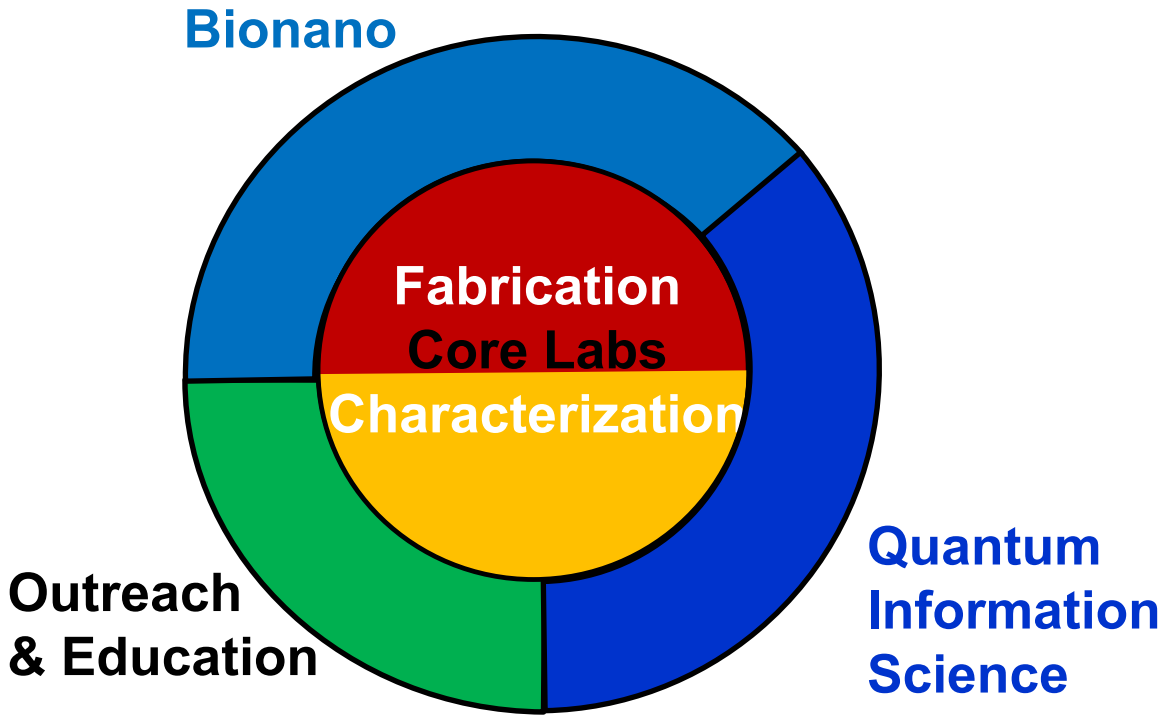


Midwest Nanotechnology Infrastructure Corridor (MINIC)

MiNIC in Years 6 to 10: Increasing Impact

- Double number of external users and publications
- Concentrate on two Focus Areas
  - Quantum Information Science
  - Nanobio
- Take a leadership role in NNCI Research Communities
- Expand outreach activities, concentrating on teachers

Focus Areas



National Nanotechnology Coordinated Infrastructure

MiNIC
Midwest Nano Infrastructure Corridor

NSF

Characterization Facility (CharFac)

www.charfac.umn.edu

- Facilities:
  - Physical Science and Engineering Building
  - Biomedical Engineering Building
  - Health Sciences Tower
- Equipment, funding, scope:
  - Analysis of hard & soft synthetic materials, liquids, biological, geological, environmental
  - Budgetary support by six colleges
  - >$20 million of equipment: ~40 major systems, ~30 ancillaries
  - 42 new systems in past 6 years
- Technical staff:
  - 12 PhD, 1 MS, >200 years experience
  - Terminal degrees in condensed matter physics (4), materials science/chemistry (4), geoscience, pharmaceutics, virology, mycology, science ed.
  - Resident data scientist, dedicated IT staffing
- User base:
  - 500-600 research users/year
  - Externals/year: 40-50 companies, 15 universities

National Nanotechnology Coordinated Infrastructure

MiNIC Midwest Nano Infrastructure Corridor

NSF

Quantum Information Science in MiNIC Y6-10

Expand processing capabilities to enable quantum information research:

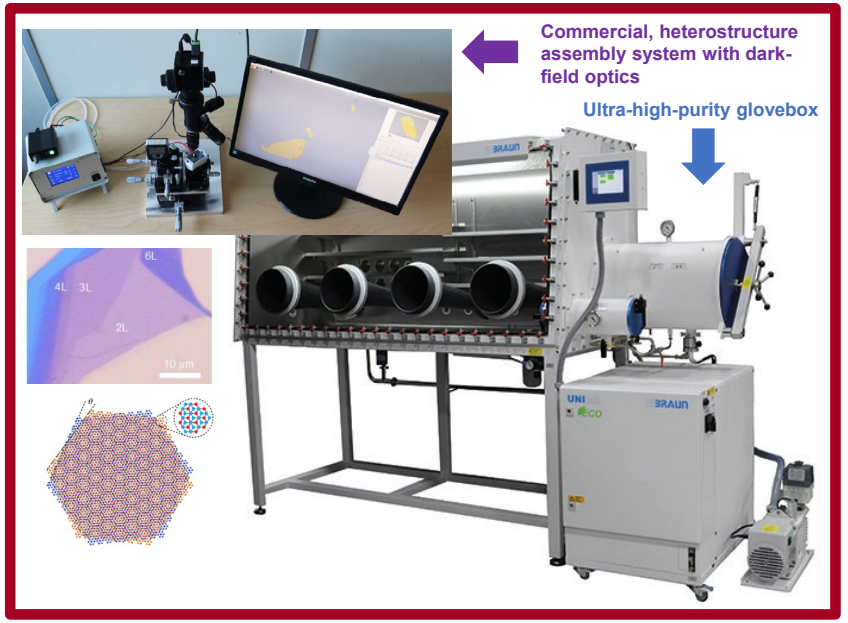
- UHV deposition system: AJA ATC Series UHV multi-target system. **Status: UMN Funded - Ordered**

Capability to deposit ultra-high purity superconductors, normal metals, dielectrics

In situ cleaning for ultra-clean interfaces

Suitable for investigation of a wide range of qubits types.

- Upgraded 2D material heterostructure assembly system: Mbraun glovebox + hqGraphene assembly system. **Status: UMN proposal submitted**



2D hetero-structures w/ ultra-clean interfaces

Positioning of reactive 2D materials

Twisted bi-layers

Nanowire assembly

National Nanotechnology Coordinated Infrastructure

MiNIC
Midwest Nano Infrastructure Corridor

NSF

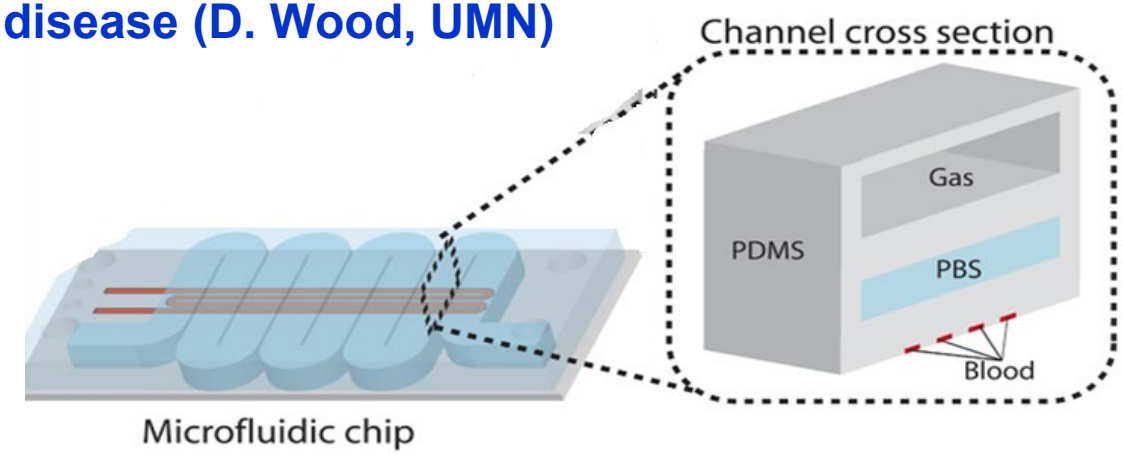
Bionano in MiNIC Y6-10

Strengths in NP suspensions

Leverage MiNIC's cleanroom for new biodevice fabrication

- Biosensors
- Medical imaging
- Organ-on-a-chip systems

A microfluidic device to simulate sickle cell disease (D. Wood, UMN)



Add new bionano tools and capabilities

- **NIH Funded -** Analytic Ultracentrifuge: analyze proteins, biomolecules, and nanoparticles via sedimentation under prolonged centrifugation at 60,000 rpm
- Instruments for chemical/physical analysis of nano-particles and dispersions
- Tools for cell, protein, and nucleic acid analysis

National Nanotechnology Coordinated Infrastructure

MiNIC
Midwest Nano Infrastructure Corridor

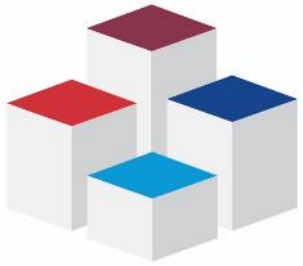
Education and Outreach in MiNIC Y6-10

- Under **MiNIC Y1-5**, we reached over 13,500 people with education programs:
  - Grad student training
  - New internship program for two-year and four-year college students
  - Short courses in 2D materials and nanomedicine
  - Tours and programs for visiting K-12 and public

- **MiNIC Y6-10** will build on these successes and add new initiatives:
- Planned activities include:
  - Nanoscience Summer Institute for Middle School Teachers (NanoSIMST)
  - Research Experience for Teachers (joint with three other NNCI nodes)
  - Webinar series on fabrication and bionano topics
  - Transitioning live programs to virtual and online offerings

MiNIC
Midwest Nano Infrastructure Corridor

Kentucky Multiscale



KY MULTISCALE

The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

"Converging Nanoscale Science with Emerging Advanced Manufacturing Technologies"

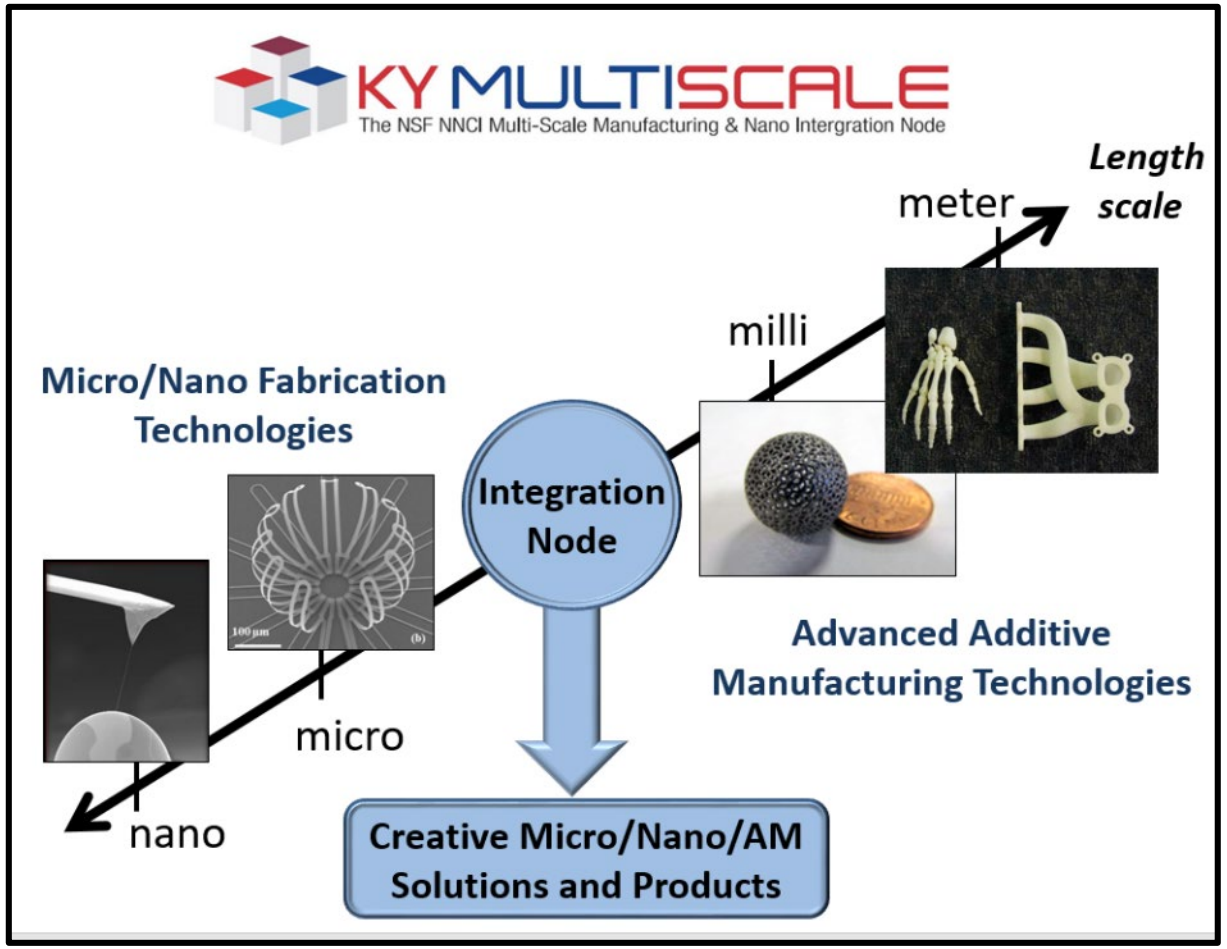
5 Minute Update
NNCI Annual Conference
Oct 26-27, 2020

KY Multiscale

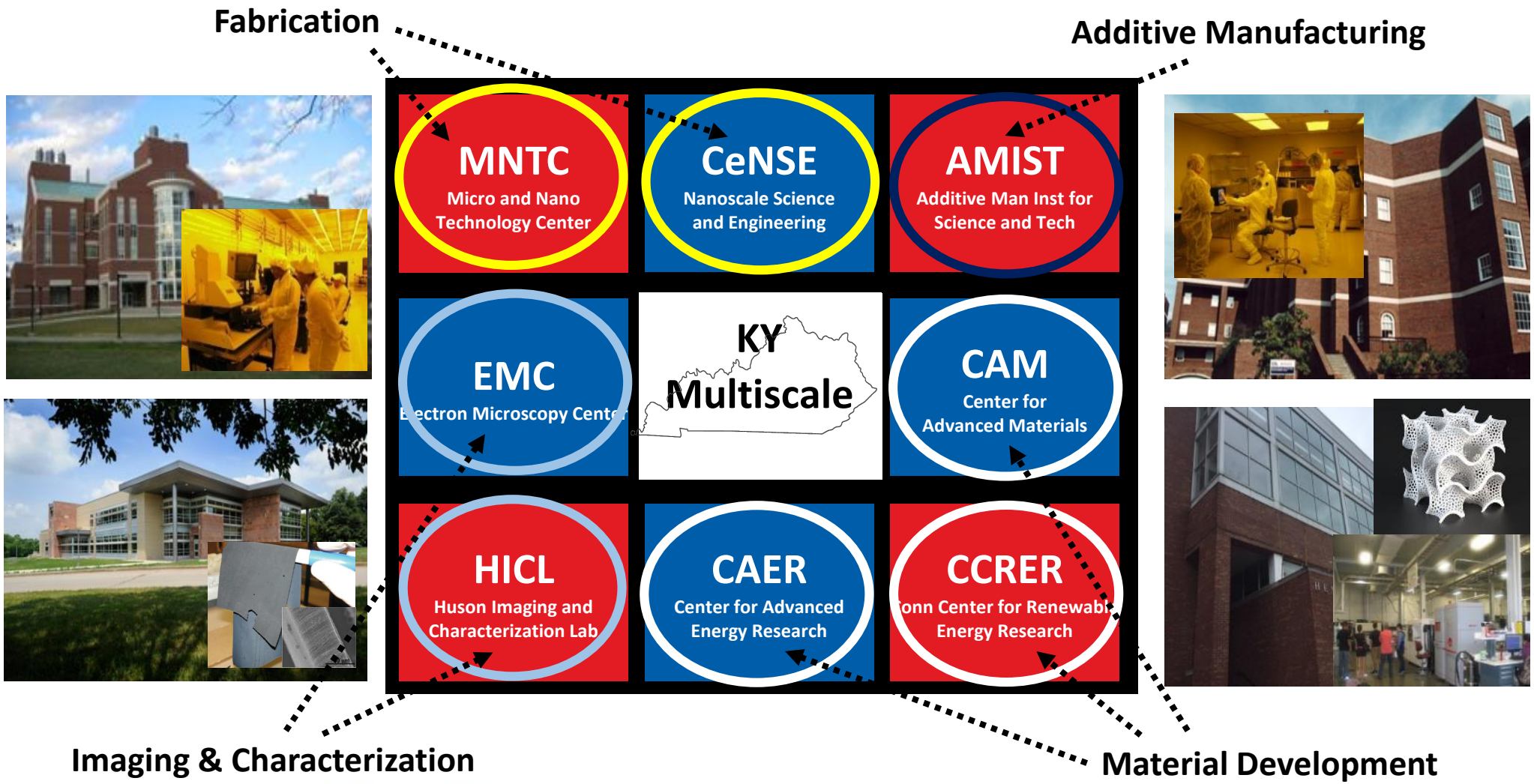
KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

www.kymultiscale.net

- Joint collaboration between UofL and UK
- Consists of 8 Advanced Manufacturing Core Facilities
- Mission – Explore the convergence of nanoscience and engineering with emerging advanced manufacturing technologies (such as 3D printing, additive manufacturing, roll-to-roll, aerosol jet printing, etc) that span across multiple lengthscales, and provide those services and associated expertise to the NNCI network and our respective state and region.



KY Multiscale – Core Facilities



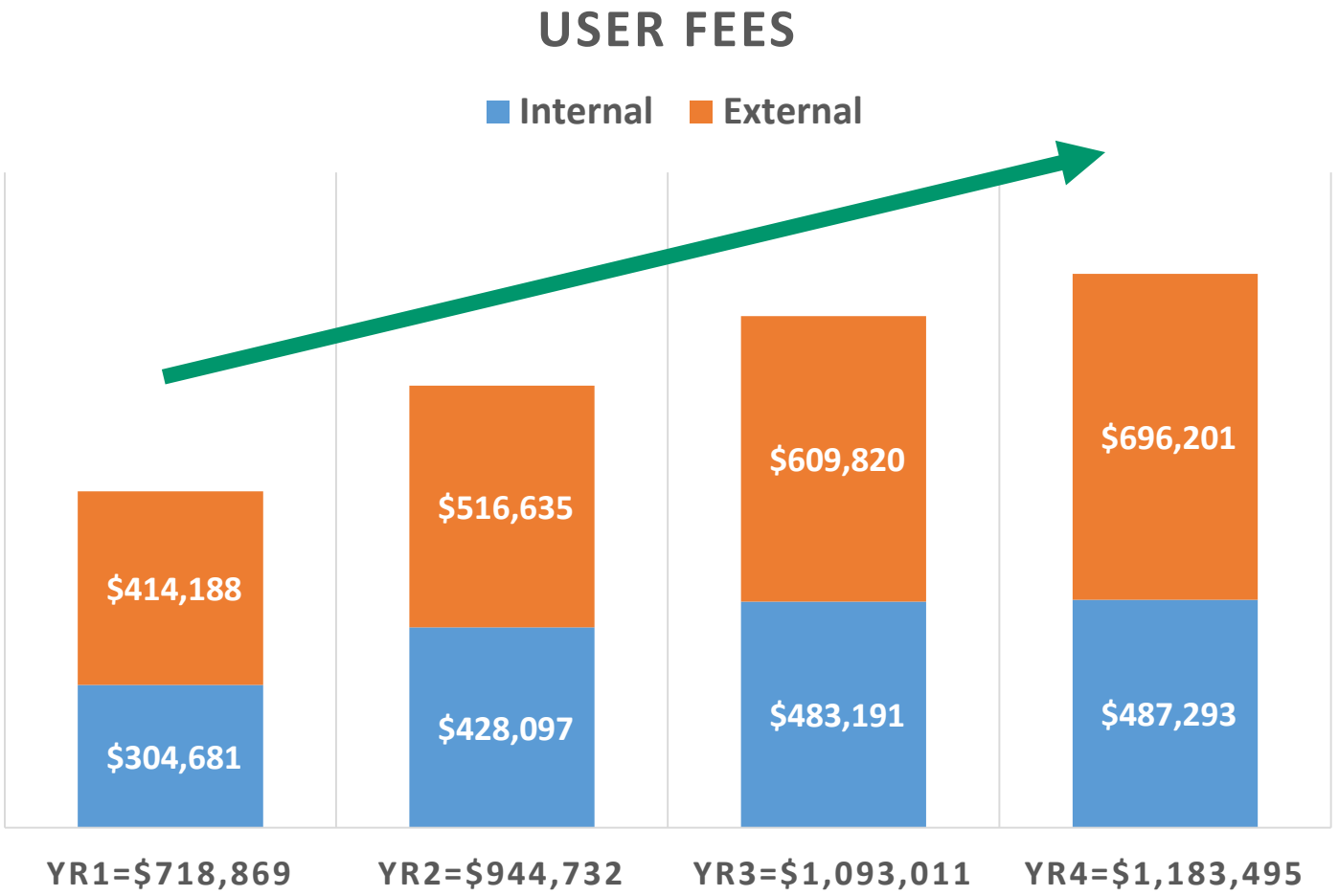
National Nanotechnology Coordinated Infrastructure

NSF

KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

KY Multiscale – NNCI Impact

- NNCI has had a very positive impact on our site and state
- Total generated user fees have increased by 65% since joining the NNCI
- 60% of our total revenue comes from external users



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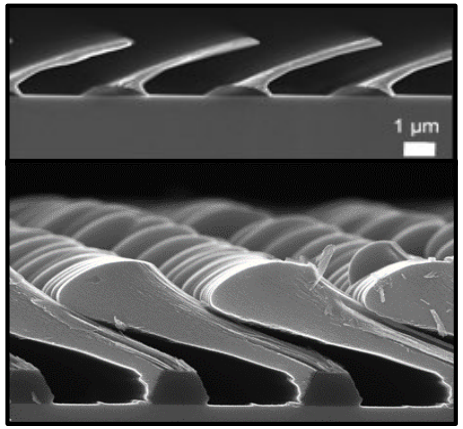
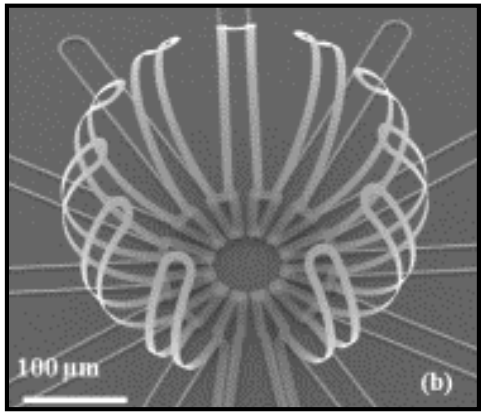
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

KY Multiscale Gen 2 - Extending 3D Capabilities

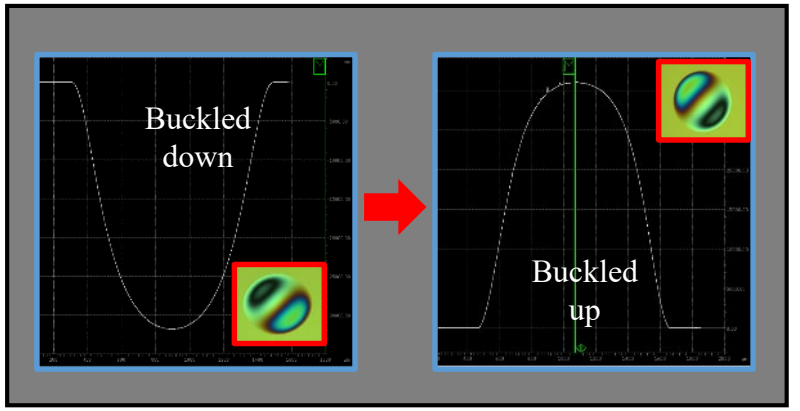
Nanoscribe Horse



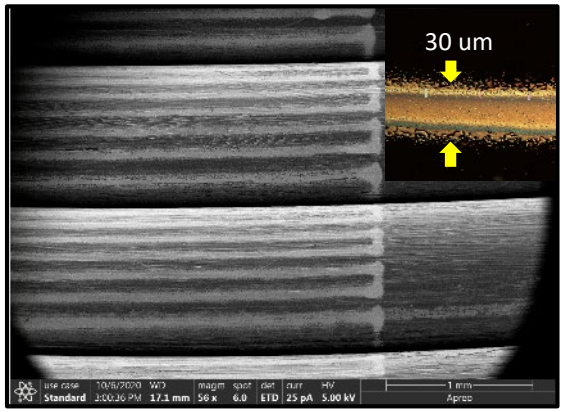
GLAD Nano-structures



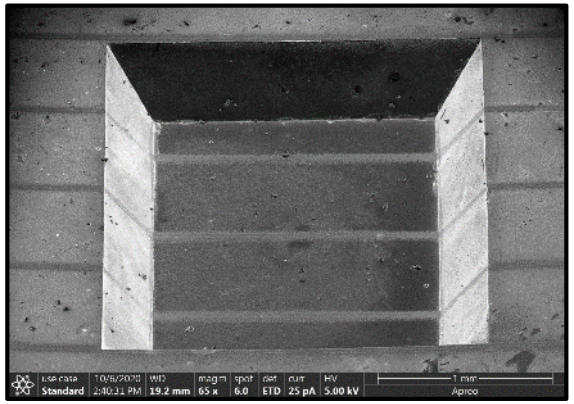
Thermal Pop-up Actuators



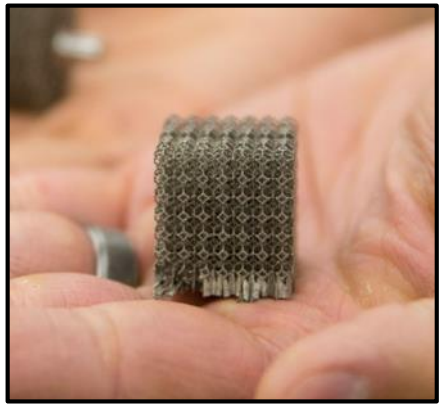
Bistable "Buckle" MEMS



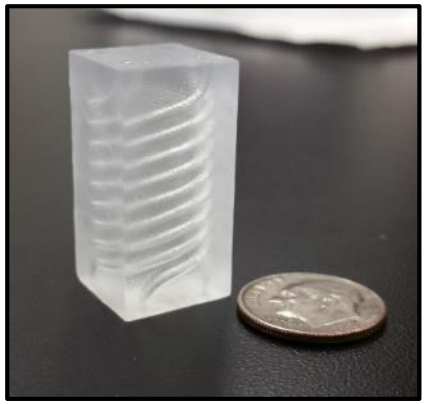
30 um Aerosol Jet Printed Silver Traces on 1mm Carbon Fiber Rods



Aerosol Jet Silver Traces in 300um Deep Silicon Micromachined Cavity



3D Printed Metal Meta-structure



3D Spiral Micro-fluidics

National Nanotechnology Coordinated Infrastructure

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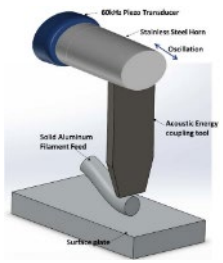
www.louisville.edu/micronano

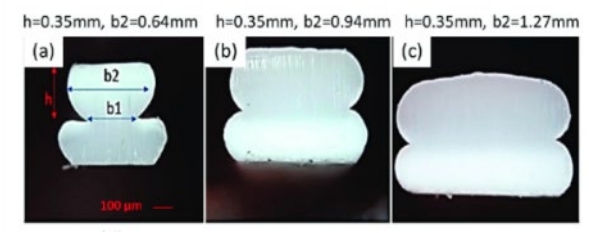
KY Multiscale Gen 2 – Key New Initiatives

1. Dedicated Site Research Communities
2. New Collaboration with HBCU FAMU-FSU
3. Expansion of our Annual KY Nano+AM Symposium
4. New NSF REU Program Directly Aligned with our Site's Nano + AM Theme
5. New Ohio Valley Regional Nano Network
6. NanoEducate: A New Middle School Teachers Training Program
7. New Seed Programs at both UofL and UK
8. Successful Partnership with KY NSF EPSCoR

Prof. Keng Hsu (UofL)

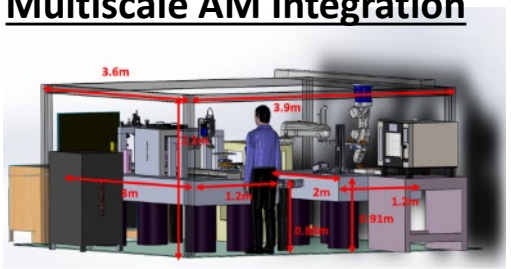
Emerging Advanced Manufacturing Technologies

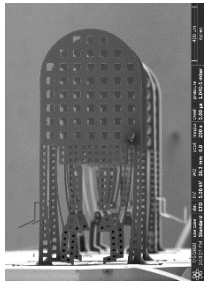


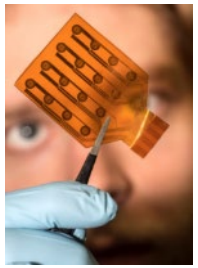


Prof. Dan Popa (UofL)

Multiscale AM Integration

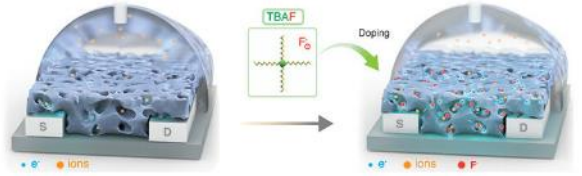




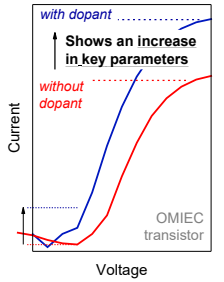


Prof. Alexandra Paterson (UK)

Printed Electronics and Sensors



Printable plastic transistor



National Nanotechnology Coordinated Infrastructure

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7. New Seed Programs at both UofL and UK
8. Successful Partnership with KY NSF EPSCoR

FAMU-FSU College of Engineering

Dr. Charmane Caldwell, collaborator and NSF Retaining Undergraduate Engineering Students grant recipient

Create a pipeline of underrepresented student researchers for KY Multiscale

National Nanotechnology Coordinated Infrastructure

KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

KY Multiscale Gen 2 – Key New Initiatives

1. Dedicated Site Research Communities

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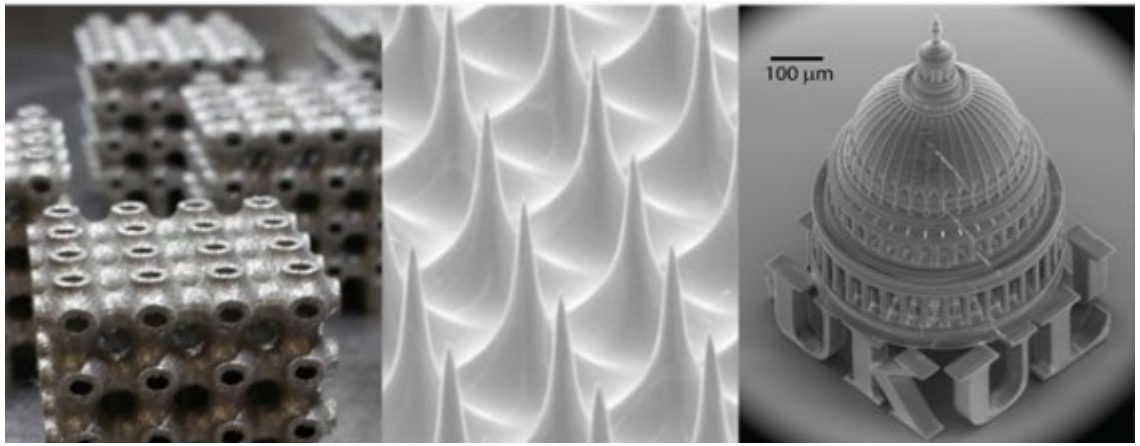
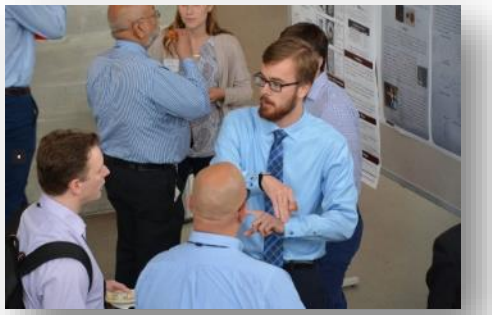
6. NanoEducate: A New Middle School Teachers Training Program

7. New Seed Programs at both UofL and UK

8. Successful Partnership with KY NSF EPSCoR

KY NANO+AM SYMPOSIUM





National Nanotechnology Coordinated Infrastructure

KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

KY Multiscale Gen 2 – Key New Initiatives

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Key Components

- Hands-on **micro/nano/additive manufacturing** training program
- 1 Personalized Independent research project
- Programs to improve oral/written communication skills
- Opportunities to learn about graduate school
- Seminars about entrepreneurship
- Lunch meetings with technical academic & industry, and government leaders
- Tours of industry manufacturing facilitites
- Ethics training
- Social activities
- NNCI Convocation attendance and hosting

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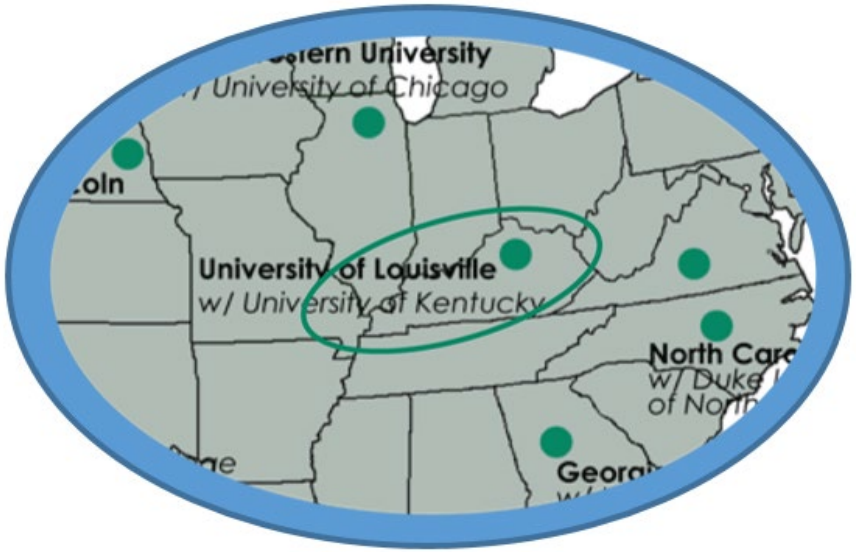

OBJECTIVES

- Build network of researchers from micro/nano/AM facilities throughout the Ohio Valley
- Exchange information on operations and capabilities, host processing seminars
- Accelerate access to KY Multiscale core facilities
- Encourage best practices and collaborative research

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Ronda Cosby, Principle

GRACE JAMES ACADEMY OF EXCELLENCE

WES West End School Louisville, KY

Carol Nord, Ex. Director

Dwight Bransford, Principle

NATIVITY ACADEMY AT SAINT BONIFACE

- Three schools serving primarily underrepresented students already confirmed for recruitment
- Summer program with materials and stipends
- Hands on summer professional development workshop about micro/nano/advanced manufacturing technologies
- Duration: 1 week
- Number of teachers: 8-10

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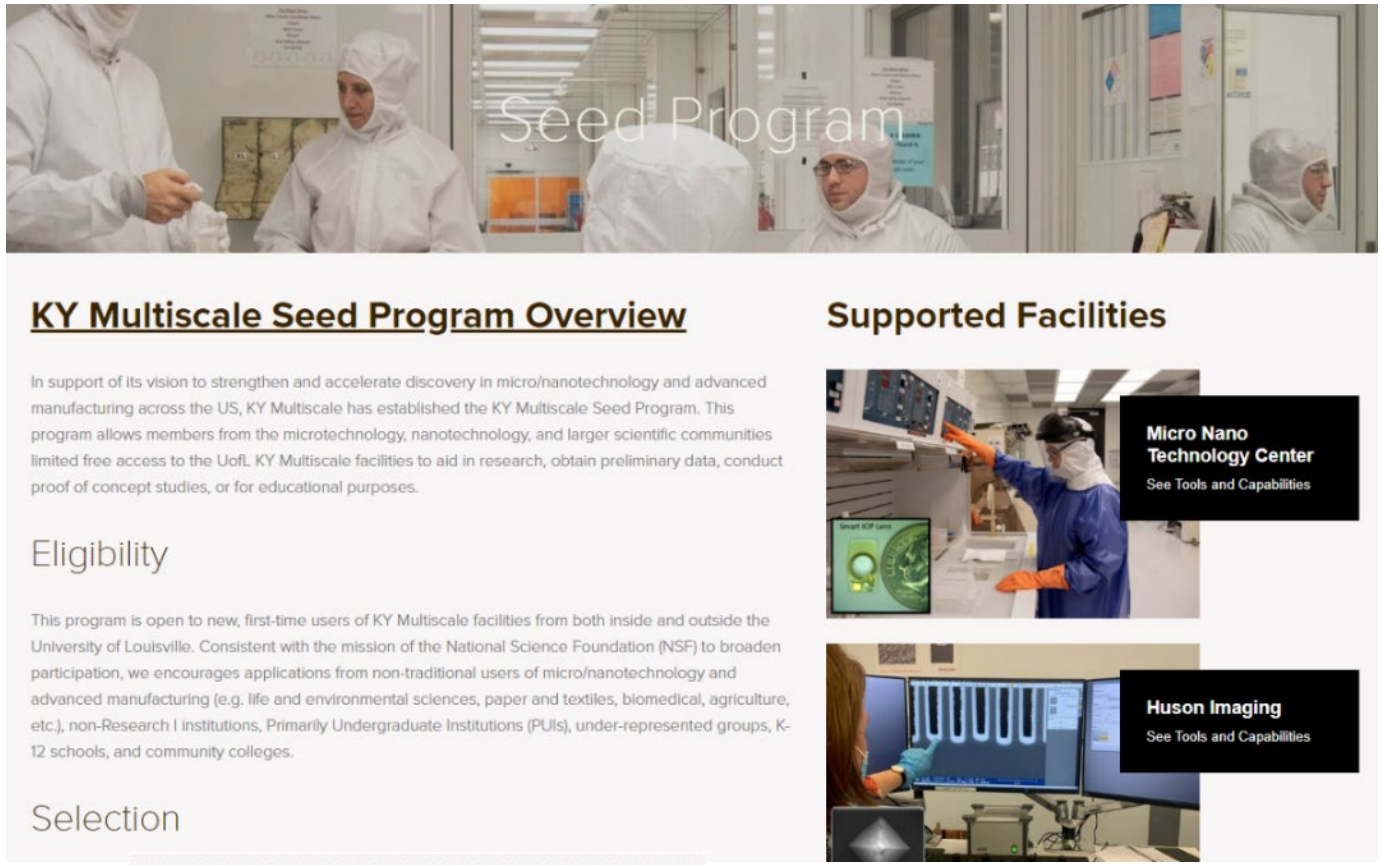

www.kymultiscale.net/seed

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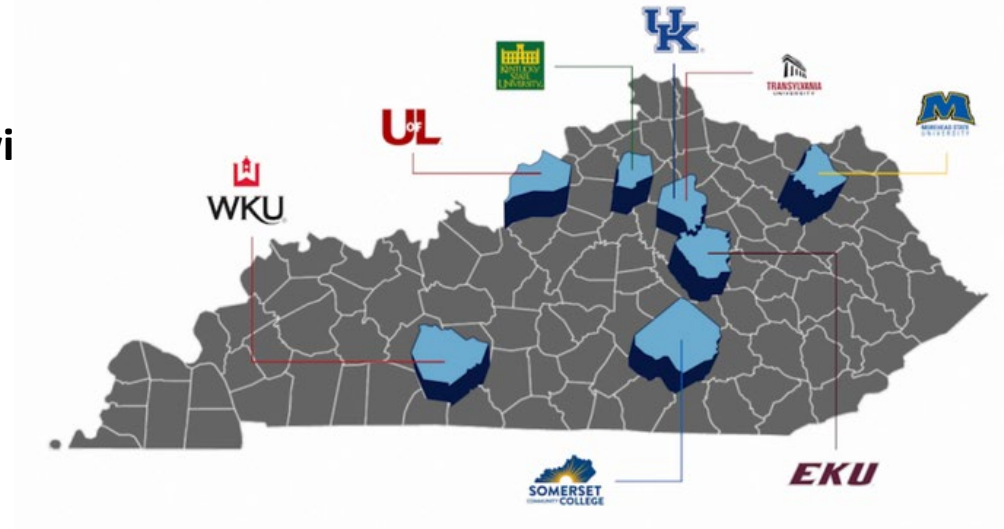
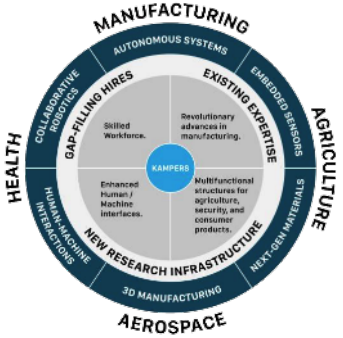
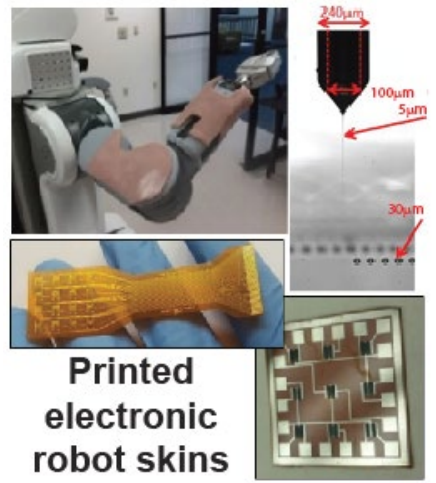
KY NSF EPSCoR







Result - $24M KY NSF EPSCOR Award: **Kentucky Advanced Manufacturing Partnership for Enhanced Robotics and Structures**

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KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

Upcoming Faculty Search

- UofL Speed School of Engineering
- ECE Senior Faculty Position
- Active Researcher
- MNTC Faculty Director
- KY Multiscale Associate Director
- Contact – Kevin Walsh

Diversity candidates highly encouraged

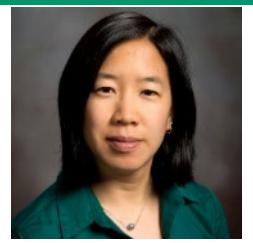
National Nanotechnology Coordinated Infrastructure

KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

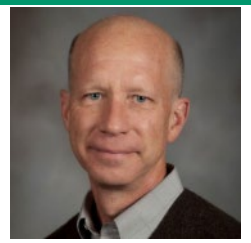
Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure (NanoEarth)

NanoEarth Team

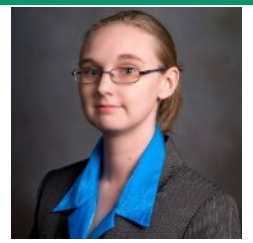
Murayama
Site Director



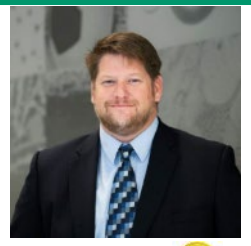
Marr
Deputy Director



Hochella
Director of User Development



Pruitt
Assistant Director



Hull
AD Innovation & Entrepreneurship

Executive Team

Michel
Geosciences

Pruden
Civil/Env. Eng.

Schreiber
Geosciences

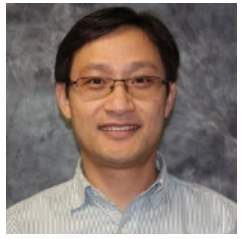
Vikesland
Civil/Env. Eng.

coPI & Technical AD

Reynolds
NCFL Director

Sowers
NCFL Admin.

Cantando
Instrument Specialist



Leng
Instrument Specialist

McCartney
Instrument Specialist

Yu
Instrument Specialist

NCFL Facility Team

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NanoEarth

NanoEarth's External Advisory Board

Dr. Nancy Hess
Environmental Molecular Sciences Laboratory, PNNL

Dr. Brett Malone
President & CEO of Virginia Tech's Corporate Research Center

Prof. Don Sparks
Dept. of Plant and Soil Science
University of Delaware

Prof. Nita Sahai
Dept. of Polymer Science
University of Akron

Prof. Emeritus Patricia Maurice
Dept. of Civil and Environmental Engineering
University of Notre Dame

Prof. Helen Hsu-Kim
Dept. of Civil & Environmental Engineering
Duke University

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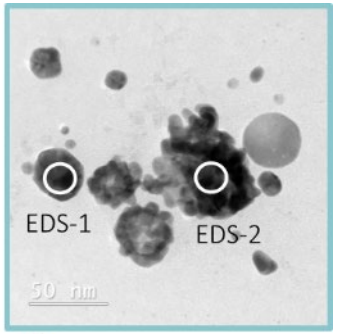
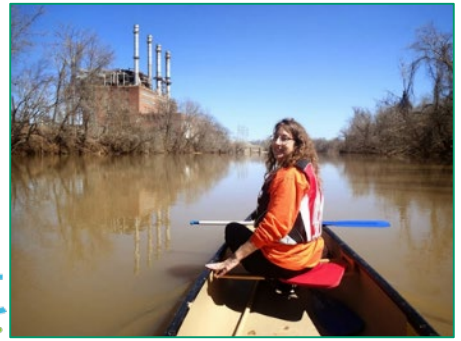
NanoEarth

NanoEarth's Mission – Reflected in New Initiatives

The mission of NanoEarth is to stimulate discovery and innovation, and to share knowledge of Earth and environmental nanoscience and nanotechnology.

- Nano Earth Systems (Nano-ES) Research Community
- Agricultural Engagement
  - Researchers: VT School of Plant & Environmental Sciences, Cooperative Extension, Government (DEQ, EPA), Industry
  - Education: 4-H & FFA





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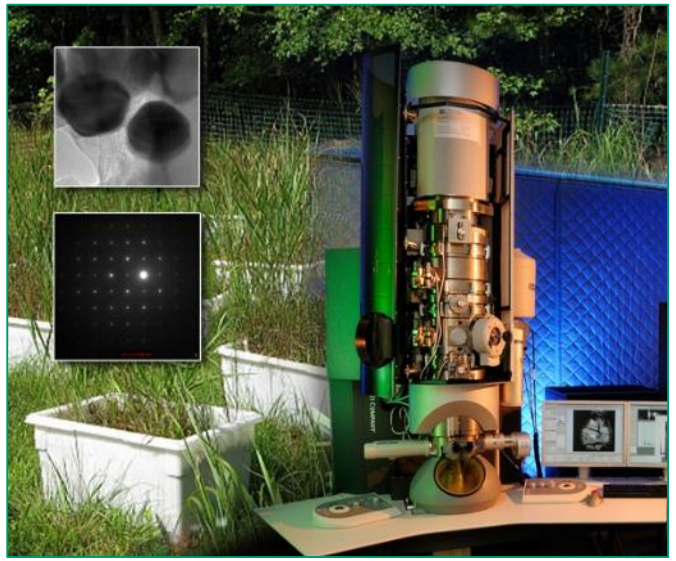
NanoEarth

Nano Earth Systems (Nano-ES) Research Community

Goal: Enhance the Earth/environmental capacity and impact of the NNCI network

Plan: Engage with NCI-SW, MONT, & nano@Stanford in activities that include:

- Participating in staff exchanges
- Formulation and documentation of best practices
- Providing workshops and coordinating summer REU activities
- Identifying and planning for future infrastructure needs



NanoEarth's co-PI Engagement & Expertise

- **F. Marc Michel**
  Associate Professor, Dept. of Geosciences; Director Nanoscience Program, (mineralogy, environmental science, and nanoscience and technology)
- **Madeline E. Schreiber**
  Professor and Associate Department Head, Dept. of Geosciences (chemical hydrogeology)

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NanoEarth

Agricultural Engagement

COLLEGE OF AGRICULTURE AND LIFE SCIENCES
SCHOOL OF PLANT AND ENVIRONMENTAL SCIENCES
VIRGINIA TECH

Virginia Cooperative Extension

Engaging Agricultural Researchers

- Leverage our existing relationships (e.g., DEQ, EPA)
- Virginia Tech Needs Assessment

Educational Outreach

- In coordination with CNF, MONT, & NNF
- Activities to include:
  - Activities at State Congress & Convention
  - Nano-related 4-H Summit (CNF lead)
- Providing a scalable opportunity that can be replicated across the NNCI

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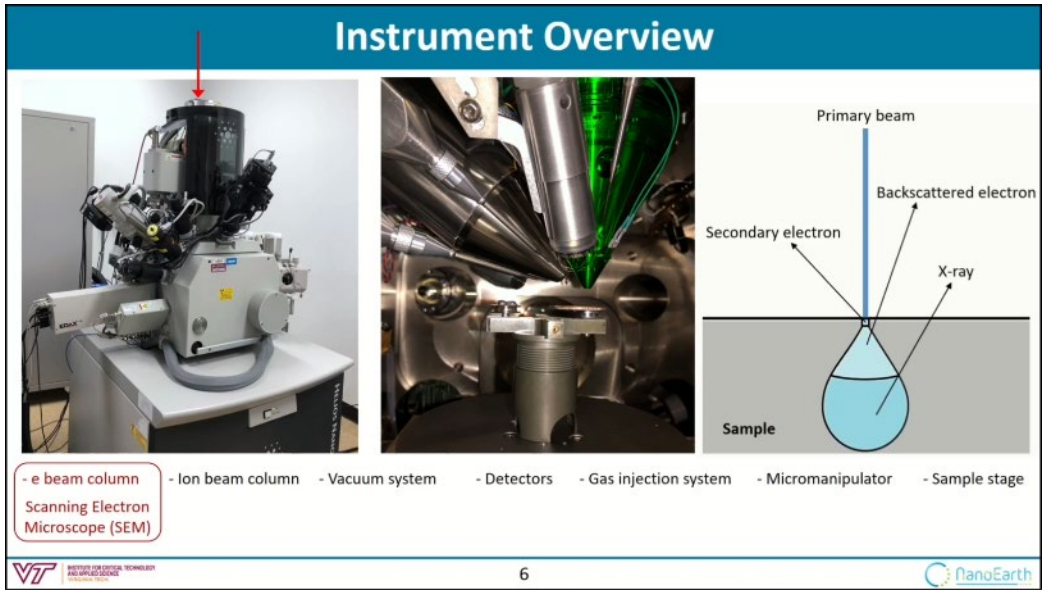
NanoEarth

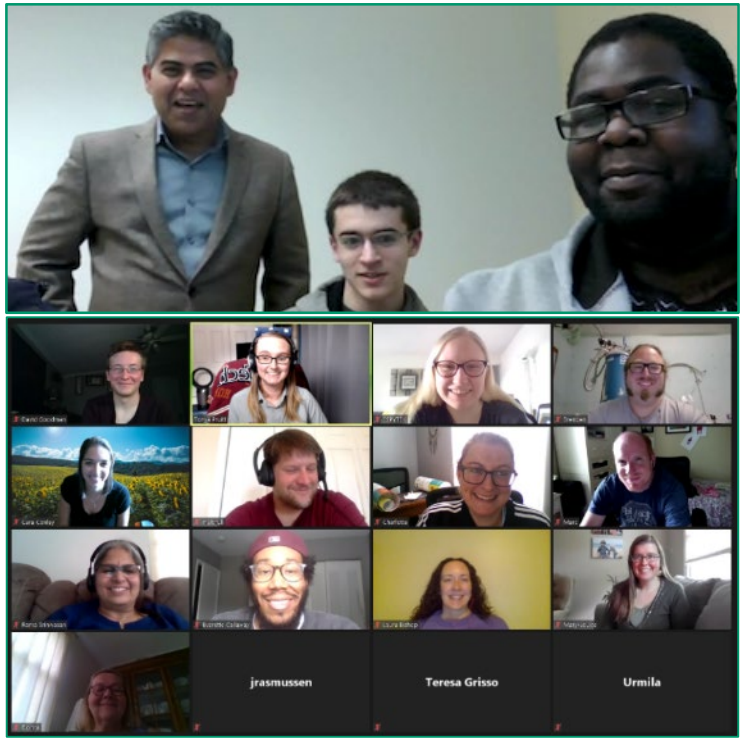
Educational Module Development & Remote Training

Pre-Pandemic Goal: **Sustainability & Growth**

- Increase sharable resources for non expert users
- Reduce “per user” staff time to accept more new projects

Pandemic Goal: **Safety & Access**





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NanoEarth

Uniquely Situated to Support COVID-19 Efforts:
Aerosols, Face Masks, Test Swabs, Sewage Testing, & Football

Halting Environmental Antimicrobial Resistance Dissemination

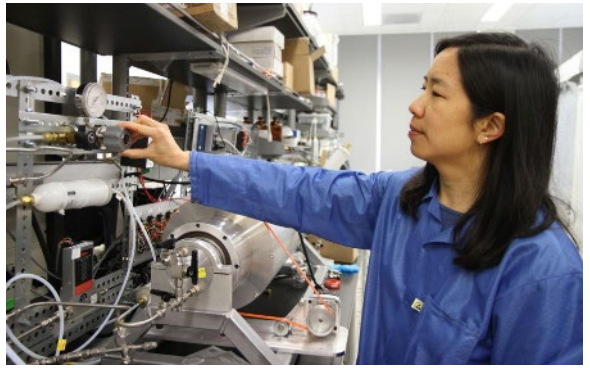
Early warning system to determine if a community is shedding virus, for resource allocation

Designing & testing the efficacy of face shields for football helmets

The New York Times

The Scientist, the Air and the Virus

Most of us had never heard of aerosol science before the pandemic. Then Virginia Tech's Linsey Marr showed up and became our tour guide to the invisible world of airborne particles.

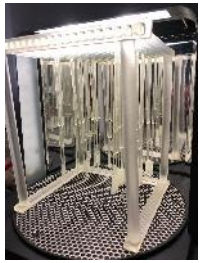


Mentioned 5,433 times in news from 86 countries reaching an estimated 14 million unique individuals.

Integrated powered air-purifying respirators (PAPRs) retrofit kit

3D Printed Test Swab Method Development & Implementation

Mechanical Testing



Post Processing

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