

NNCI MANTH: Mid-Atlantic Nanotechnology Hub



An NSF-National Nanotechnology Coordinated Infrastructure Node

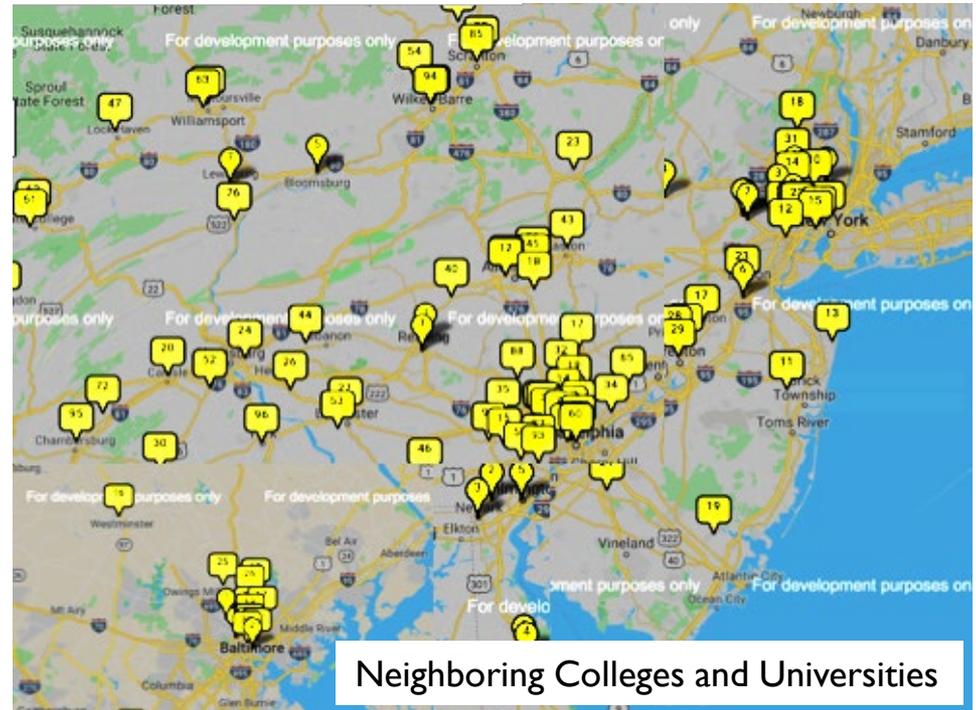
Singh Center for Nanotechnology, University of Pennsylvania; and Community College of Philadelphia

October 2019 NNCI Annual Meeting, Harvard University

Mid-Atlantic Nanotechnology Hub - MANTH

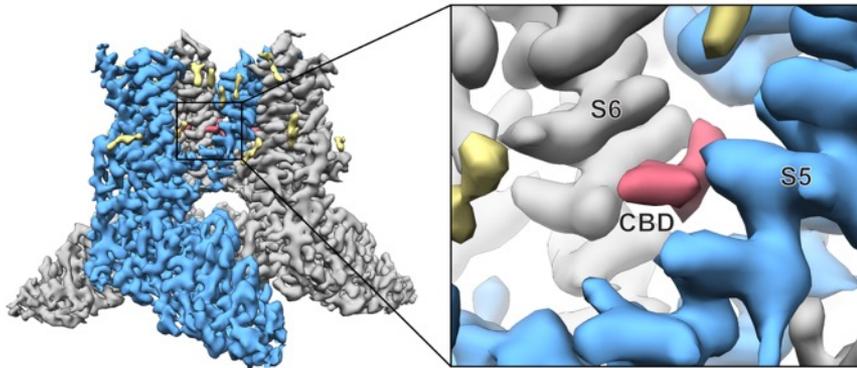
- We strive to be a catalytic force for nanotechnology in the industry-dense and academically-rich environment of the mid-Atlantic region in a centrally-located Philadelphia hub
- We enable exploitation of fundamental advances in nanoscience to realize nanotech materials, devices and systems by being a ‘maker space’ for nanotechnologists
- MANTH comprises:

- Quattrone Nanofabrication Facility (all aspects of nanofabrication)
- Nanoscale Characterization Facility (characterization through electron and ion beams)
- Scanning and Local Probe Facility (characterization through scanning probe)
- Our partner, the **Community College of Philadelphia**, who we work with to develop educational programs for future “nano-aware” technicians



MANTH: Facilities and Tools

- Over **\$11 Million** invested in equipment in the past year
- New Microscope Lab for Life Sciences and Materials Research – Krios Cryo-TEM at the Singh Center
 - Available to Penn and external academic research groups in the greater Philadelphia area.
- Technical Director: Dr. Darrah Johnson-McDaniel Ph.D. Inorganic Chemistry, U. Georgia; several years industry experience



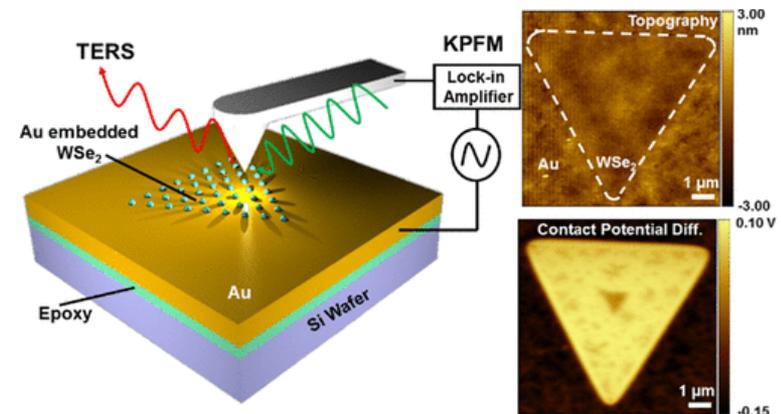
Pictures of molecules: Imaging of a Transient Receptor implicated in the function of glioblastoma; Cannabidiol is a TRPV2 agonist



MANTH: Facilities and Tools

Quantum Leap
Harnessing the Data Revolution
Human/Technology Frontier

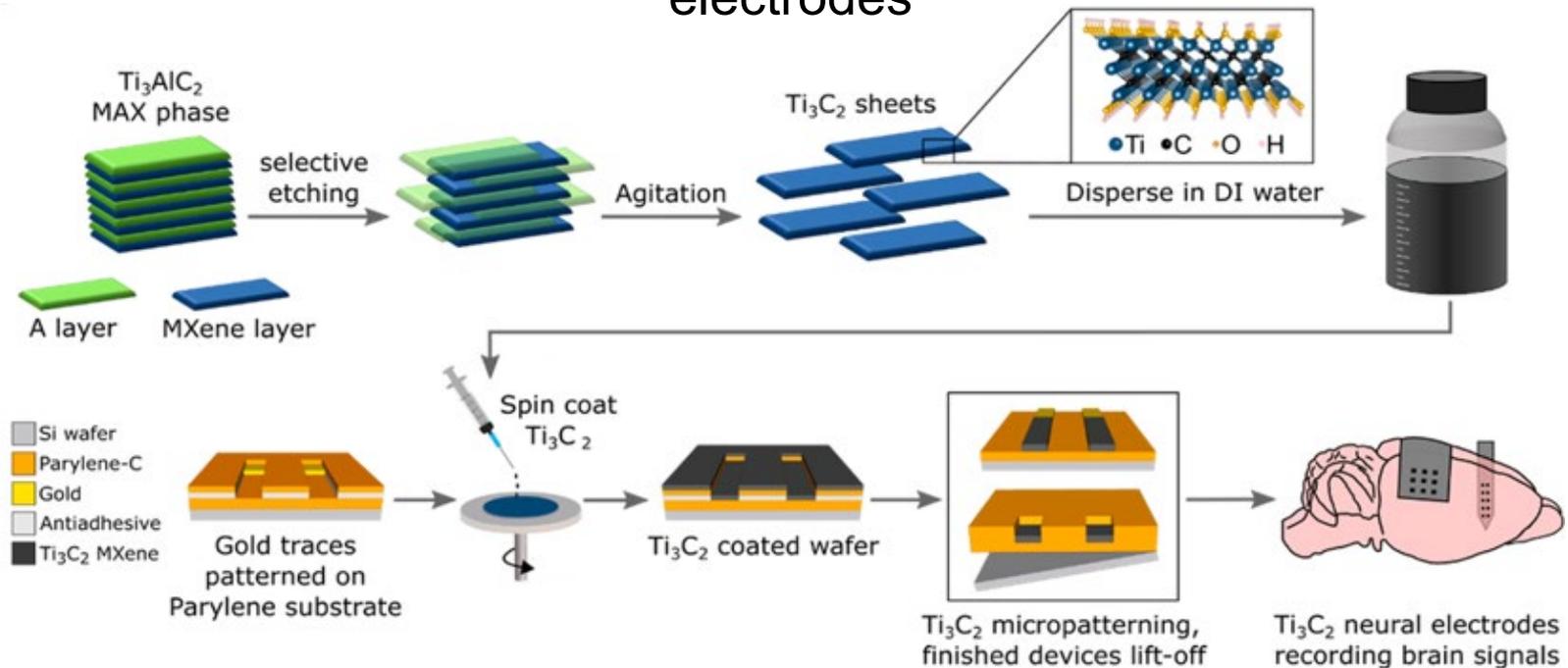
- New deposition reactor for synthesizing 2D chalcogenide materials
 - A unique configuration with 2 reactors, horizontal and vertical chambers
 - 2 metal (Mo, W) and 2 chalcogenide (Se, S) sources
- Applications
 - Studying Quantum phenomena
 - New photonic devices
 - New electronic devices/sensors
 - New catalysts for energy storage



MANTH: Research Highlights

Two-Dimensional Ti_3C_2 MXene for High-Resolution Neural Interfaces
(Penn Medicine, Drexel, MANTH REU student)

High surface area, low impedance, mechanically flexible, neurocompatible electrodes

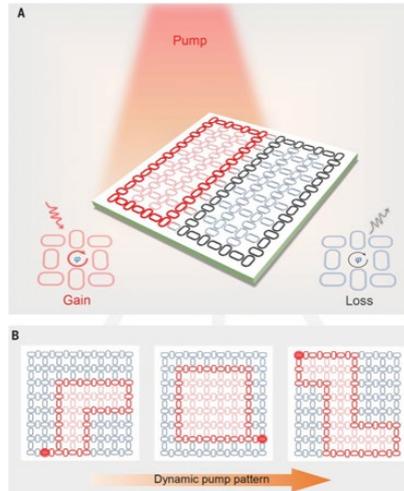


Driscoll, N., et al., "Two-Dimensional Ti_3C_2 MXene for High-Resolution Neural Interfaces," *ACS nano*, 12(10), pp.10419-10429 (2018).

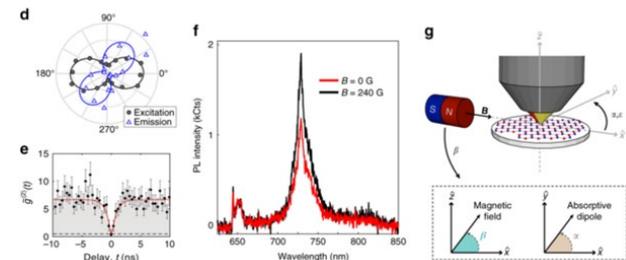
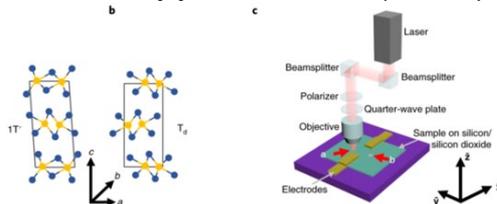
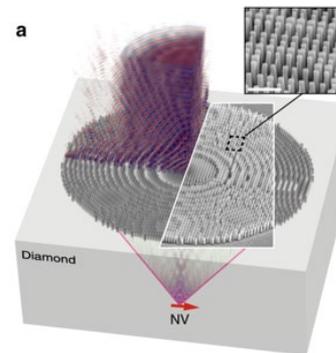
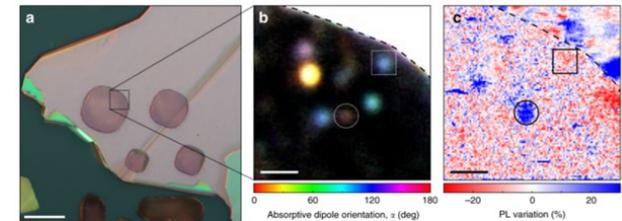
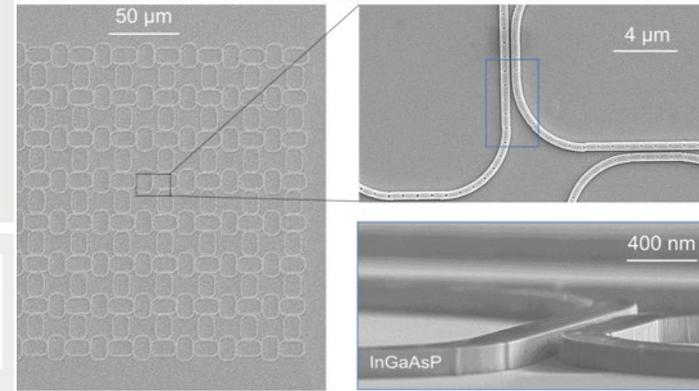
MANTH: Research Highlights

Quantum Leap
Convergence Research

- Non-Hermitian topological light steering: H. Zhao, L. Feng, et al., *Science*, Vol. 365, Issue 6458, pp. 1163-1163 (2019).
- Magnetic-field-dependent quantum emission in hexagonal boron nitride at room temperature: A. Exarhos, L. Bassett, et al., *Nature*, Vol. 10, Issue 1, pp. 222-8 (2019).
- A monolithic immersion metalens for imaging solid-state quantum emitters: T. Huang, L. Bassett et al., *Nature Communications*, Vol. 10, Number 1, 2392 (2019).
- Spatially dispersive circular photogalvanic effect in a Weyl semimetal: Z. Ji, C.L. Kane, E.J. Mele, R. Agarwal et al., *Nature Materials*, Vol. 18, Issue 9, pp. 955-955 (2019).



A quantum explosion!





Symposium: Enabling Quantum Leap: Achieving Room-Temperature Quantum Logic through Improved Low-Dimensional Materials

- This NSF-Funded workshop at MANTH explored the needs and challenges involved in ensuring the advancement of quantum logic with improved low-dimensional materials operating at room temperature.
- Attendees from NSF and 17 Universities

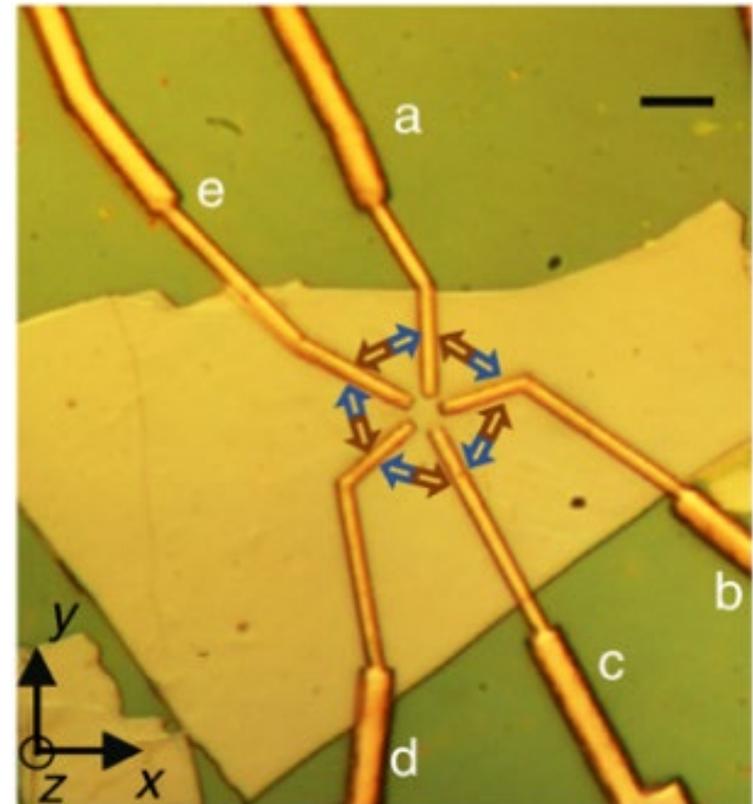


MANTH: Research Highlights

Quantum Leap
Convergence Research

NSF Research Advanced by Interdisciplinary Science and Engineering (**RAISE**)
Engineering Quantum Integrated Platforms for Quantum Communication (**EQuIP**)

- **RAISE-EQIP Grant:** Integrated Higher-Dimensional Quantum Photonic Platform
- Collaboration between Penn Engineering (Liang Feng and Ritesh Agarwal) and Stevens Institute of Technology (Stefan Strauf)
- Fabrication of nanophotonic devices with unique materials is essential in advancing quantum communications research

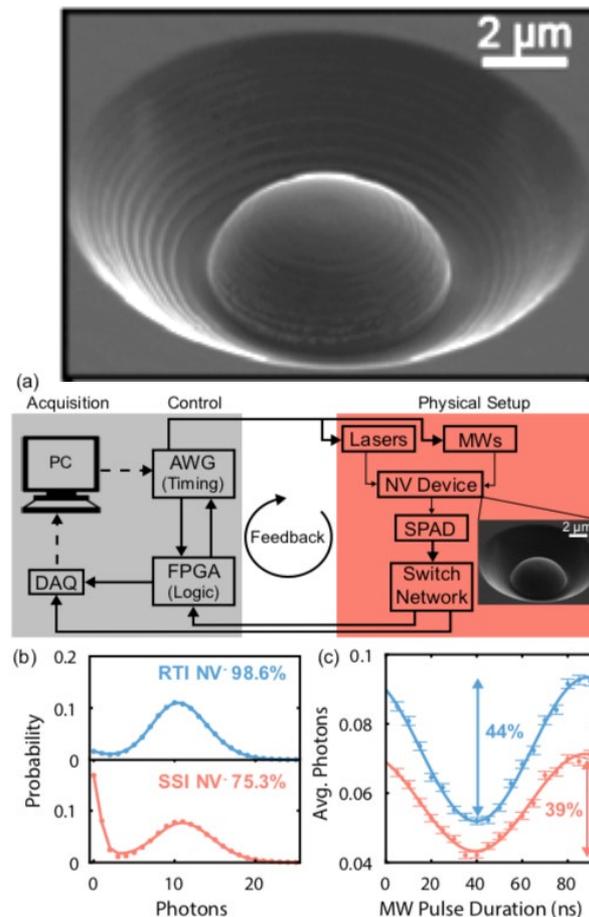


MANTH: Research Highlights

Quantum Leap
Convergence Research

NSF Research Advanced by Interdisciplinary Science and Engineering (**RAISE**)
Engineering Quantum Integrated Platforms for Quantum Communication (**EQuIP**)

- **RAISE-EQIP Grant:** Chip-Scale Quantum Memories for Practical Quantum Communication Networks
- Collaboration between Penn Engineering (Lee Bassett and Firooz Aflatouni) and Brown University (Rashid Zia)
- Leveraging modern capabilities in materials science, nanofabrication, signal processing, and integrated systems-on-a-chip to harness the computational power and sensitivity of quantum-coherent systems for practical applications.

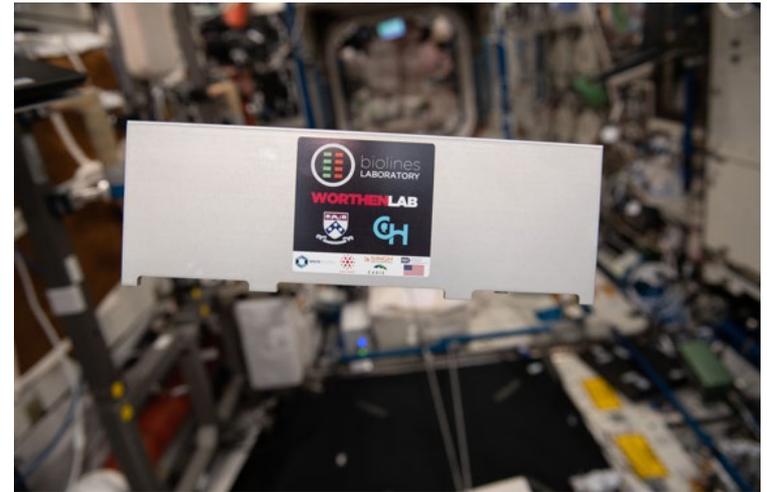


MANTH: Research Highlights

*Understanding the Rules of Life
Windows on the Universe*

NIH/NCATS: Microfluidics in Space!

- Collaboration between Penn Engineering (Dan Huh) and Children's Hospital of Philadelphia (Scott Worthen)
- A little-known fact about space travel is that astronauts often get sick with colds and lung infections during their time away - much more frequently than on Earth.
- Recruitment of the immune system to battle disease in space can be observed through microfluidically-enabled organs on a chip
- Goal is to improve ability to protect astronauts during long voyages to the Moon, Mars, and beyond.



MANTH: Education and Outreach

NSF INCLUDES



REU Program

2019 Cohort (N=6, 100% response to anon feedback survey)

- all responded that REU increased interest in STEM
- Ranked 4.7 on scale of 1-5 (5=highest) on value of REU for academic, scientific, professional, personal growth
- all would recommend program to peers

Alums (2016-2018; N=18)

- 9 in PhD programs (2 NSF Grad Res Fellows), 2 in Master's or post-bac programs
- 2 in STEM jobs
- 3 of 4 of the continuing undergrads known to have participated in research/industry internships during summer after their NNCI REU



NanoDay@MANTH (Oct. 9, 2018)

- Students (N=104): Interest in STEM (67 (64.4%) increased, 25 (24%) stayed same, 5 (4.8%) decreased); ave 4.1 out of 5 (best) rank for visit
- Teachers (N=8): Value of visit for students (ave rank) = 4.8 out of 5 (very valuable); Stimulated ideas for teaching STEM (ave rank) = 4.7 out of 5 (strongly agree)

MANTH: Education and Outreach

Community College of Philadelphia Initiatives

Fall 2019: Additive Manufacturing Course (ASET 140, Lecture and Lab): 8 students enrolled

Spring 2020: Intro to Nanotechnology (ASET 201)

Community College of Philadelphia ASET 140: 3D Printing—Additive Manufacturing Fall 2019

Instructor: Randy Libros
Phone: 215-751-8583

Office: W4-31
Email: rlibros@ccp.edu

Class meeting time:

Lecture 1:00-2:30 Tuesdays and Thursdays
W4-37

Lab 2:40-5:40 Tuesdays
W4-37

Office Hours:

Monday 8:00-9:00 PM—appointment highly recommended

Wednesday 1:30 PM-3:30 PM—open office hours—no appointment needed

Wednesday 4:30-5:30—appointment highly recommended

Thursday 3:00 PM – 5:00 PM—appointment highly recommended

Text Book: [ToolingU/SME on-line course bundle for Additive Manufacturing](#)

Course Description: Welcome to ASET 140. Additive manufacturing (AM), also referred to as 3D printing, is a process of creating objects by building them up layer by layer. This course will provide hands-on experience with 3D printers as well as introduce applications of AM in the manufacturing sector. This course may be applied to the Applied Science and Engineering Technology degree, and may be of interest to students in other curricula.

Upon completion of this course students will be able to:

1. Define terms and acronyms related to additive manufacturing and identify or explain basic concepts of 3D CAD files and [the .stl](#) file format
2. Describe basic concepts of the manufacturing process and the ways in which additive manufacturing is affecting and transforming manufacturing
3. Solve problems related to volume, area and basic geometric shapes
4. Perform unit conversions between US customary and International System Units
5. Define current additive technologies (currently this includes technologies such as SLA, SLS, FDM, and high speed sintering) and compare and contrast their uses in various applications
6. Differentiate between industrial and consumer equipment in relation factors such as materials, print quality, and post processing,
7. Describe procedures for setting up an AM part run.
8. Explain the importance of instrument calibration
9. Practice safe work procedures in the lab



Local College Educational Outreach

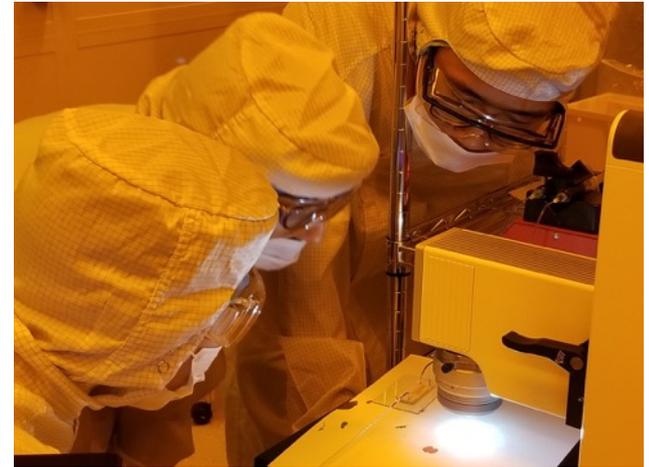
- MANTH program for undergraduate students from local colleges and universities
- Hands-on fabrication using the tools in the cleanroom
- Photolithography, RIE, and characterization processes incorporated in the program
- 47 Students from Swarthmore, Villanova, and Bryn Mawr attended last Fall and Spring
- Expanding program next year to include students from Jefferson University and CCP



MANTH: Education and Outreach

Engineering Summer Academy at Penn: Nanotechnology

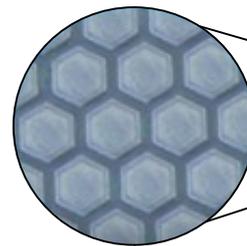
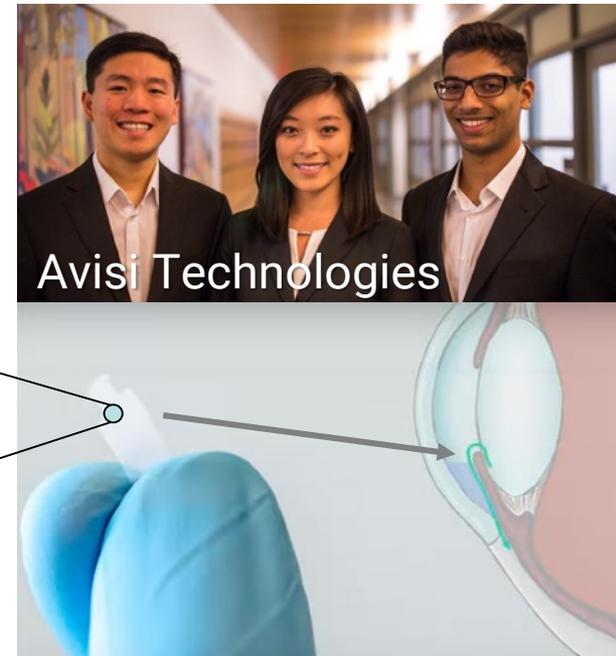
- 3 week resident program (July 2019)
- 34 High School students - 30% international, 50% women
- 10 Instructors and TAs (3:1)
- 3 hands-on lab modules - microfluidics, quantum dots, micro-3D printing, and “micro-letters”
- Students used over 20 fab tools and participated in demos of SEM, TEM, and FIB
- Oral and poster presentations
- Industrial fieldtrip to Dow (18 Scientists prepared demos, tours, and participated in a panel discussion)
- Career talks from researchers, engineers, and entrepreneurs (Avisi and InnaMed)



Translational and Commercialization Impact

- 2018 Innovation Seed Grant
 - 11 Finalists (matriculation April 2018)
 - Awarded \$20.1k of tool access (academic rate)
 - ~\$4.3 million VC raised since matriculation
 - Full Year ROI: \$448 raised for every \$1 used from the award
- Highlighted Startup Companies
 - Medical Device:
 - Therapeutic Articulations, LLC
 - InnaMed, Inc.
 - Volta Therapeutics
 - Dragon Spectral
 - Paper Based HIV POC Device
 - Avisi
 - PolyAurum LLC
 - Environment: Folia Water
 - Optoelectronics: NanoGrass Solar LLC
 - Sensors: Chromation

Company Name	Total Received [USD]
InnaMed	\$1,000,000
Folia Water	\$1,753,750
Chromation	\$1,250,000
NanoGrass Solar LLC	\$300,000



MANTH: Impact

*Understanding the Rules of Life
Quantum Leap
Harnessing the Data Revolution
Human/Technology Frontier*

Translational and Commercialization Impact

- **2019 Innovation Seed Grant**
 - 7 Startup Companies (matriculation April 2019) selected by an external panel active in the Philadelphia startup community
 - Awarded \$18.5k of tool access (academic rate)
 - **\$2.2** million VC raised since matriculation
 - ROI: **\$191** raised for every \$1 used from the award
- **Startup Companies**
 - Medical Device:
 - Therapeutic Articulations, LLC
 - InnaMed, Inc.
 - CubIMM
 - Mitology
 - Volta Therapeutics
 - Optoelectronics: NanoGrass Solar LLC
 - On-Chip Testing: XALLENT LLC

External Judging Panel



Victoria Berenholz
Penn Health-Tech



Laurie Actman
Penn Center for
Innovation



Sasha Schrode
Robin Hood
Ventures



Donna Cordner
OKM Capital



Michael Poisel
Penn Center for
Innovation Ventures



Matt Bell
NextFAB

MANTH: Panel Discussion

Aligning NNCI with National Research Priorities

Future of Work

Growing Convergence Research

Harnessing the Data Revolution

Mid-scale Research Infrastructure

Navigating the New Arctic

NSF 2026

NSF INCLUDES

Quantum Leap

Understanding the Rules of Life

Windows on the Universe

- Nanotech is already the enabler of many of the NSF big ideas. We must emphasize what we already do and how it impacts these ideas: quantum leap, life sciences, big data, human interfaces, future of work, outreach, ...
- AND: we may need to think about an 'advertising' program within and without our community: NNCI Inside? (NNI does this well, more broadly)
- Perhaps an opportunity to highlight our importance at the NAE review of the NNI?
- Highlight our role in training the hands-on nano workforce for future industry needs
- Marketing ourselves as solution providers/contributors to solutions for other agencies' challenges

Grand Challenges Report	Engineer Better Medicines	Provide Energy from Fusion
Advance Personalized Learning	Advance Health Informatics	Prevent Nuclear Terror
Make Solar Energy Economical	Restore and Improve Urban Infrastructure	Manage the Nitrogen Cycle
Enhance Virtual Reality	Secure Cyberspace	Develop Carbon Sequestration Methods
Reverse-Engineer the Brain	Provide Access to Clean Water	Engineer the Tools of Scientific Discovery

Press Releases from the NNI Community

Nanotherapy Improves Chemotherapy Delivery

Use of nanopores could lead to cleaner water

Detailed picture reveals how tooth enamel is strong enough to last a lifetime

[more »](#)

NNI in the News

That new yarn? -- wearable, washable textile devices are possible with MXene-coated yarns

New production technique for high-performance polymer could make for better body armor

Bacteria trapped—and terminated—by graphene filter

