MANTH: The Mid-Atlantic Nanotechnology Hub
Post-NNCI Sustainable Programs

"What are examples of programs and activities developed under NNCI that will be sustainable, independent of any continued NSF renewal funding, and what strategies or sources will be used to support them?"

- Nano Day Outreach Program
- Graduate Student Fellows Program: A Workforce Development Ecosystem
  - Fellows Support Staff in Process Development
  - Fellows Support Faculty as Teaching Assistants for Center-Based Lab Courses
- Staff-centric network interactions (old and new)
  - MAEBL
  - Cleanroom Manager Workshops
  - …
- Entrepreneurial User Development

These initiatives developed under the NNCI program have significant benefit - financially, reputationally, or both - to Penn, to the Community College of Philadelphia, and to the Singh Center. There is significant institutional interest in maintaining them.

NanoDay @ Penn – for K-12, Scale Up by Decentralization

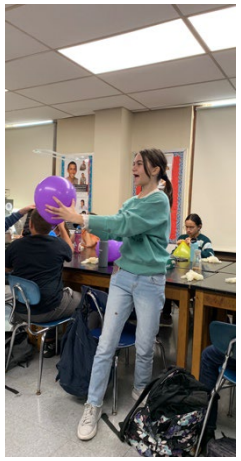
Pre-pandemic: Confined space

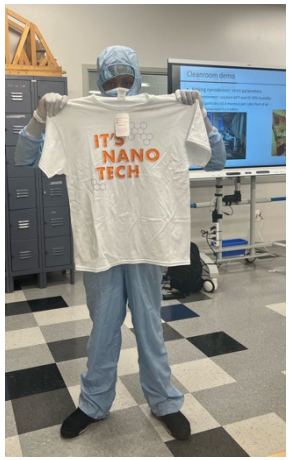
Comments from students in 2018

- Love it. Great tour guides.
- I had a ton of fun and love the entire experience except the window tour, because it was hard to understand and pay attention. Would have loved a shorter window tour and more hands-on stuff, because everything else was great.
- Sean was an excellent guide and facilitated the experience well. At some stations, I felt we didn't have enough time to fully experience the technology.

Student perception: demo & tour

Post-pandemic: Unbound space





Comments from students in 2023 and 2024

- The most interesting part was the magnets and the pencil, as well as how the plastic floated above the balloon. It was one of my highlights because I've never seen anything like it before and why it happens like that.
- Seeing the change in voltage due to the energy generated by the solar panels. I also liked learning about how solar panels are made, and how efficient they are as a renewable energy resource.
- I liked putting on goggles and gloves because it made me feel professional.
- How folding material could make crazy art.

Student perception: hands-on experience

National Nanotechnology Coordinated Infrastructure NSF

SINGH Center for Nanotechnology
Mid-Atlantic Nanotechnology Hub

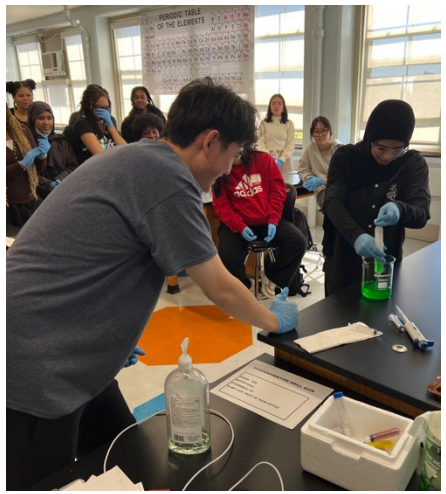
Penn

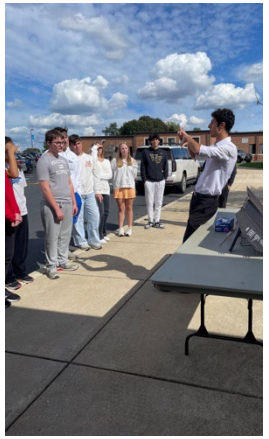
Community College of Philadelphia

NanoDay @ Penn – for K-12, Scale Up by Decentralization

NanoDay @ Penn 2024 Photos









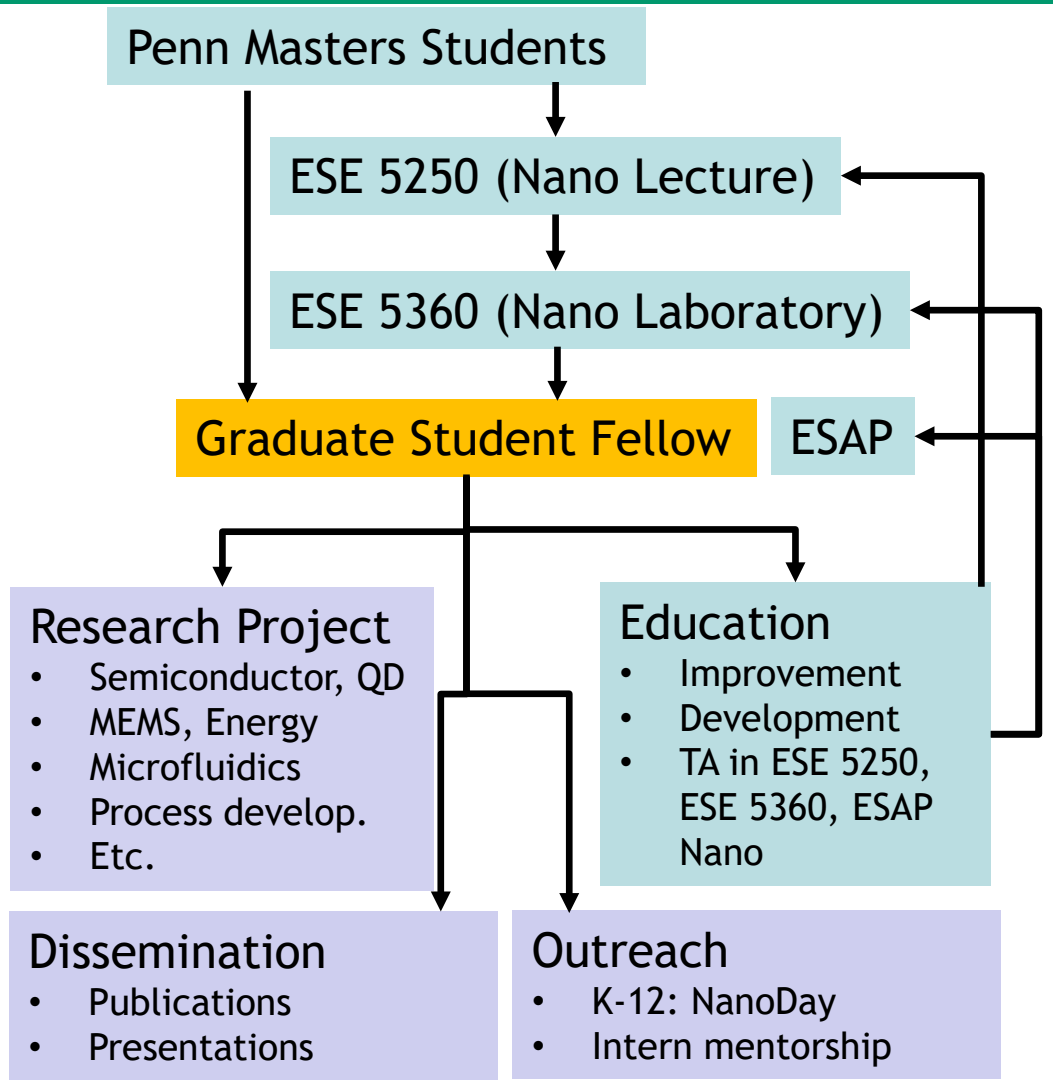
National Nanotechnology Coordinated Infrastructure NSF

SINGH Center for Nanotechnology
Mid-Atlantic Nanotechnology Hub

Penn

Community College of Philadelphia

Graduate Student Fellowship Program – A Workforce Development Ecosystem for Masters' Students



GSF (Graduate Student Fellow) program

- Since 2015. 1 year program. Core workforce of QNF

GSF students

- **2nd year Master's student in Nanotechnology, ESE, MSE, BE, MEAM and CBE**
- **A total of 129 GSFs since 2015**
- Gender ratio as of Oct 2024
  - Male : Female = 85 : 44

Roles and responsibilities

- Individual research project (at least 1 device project per student)
- TA in ESE 5250,5360/3360, Engineering Summer Academy at Penn (ESAP) Nano
- Mentoring and including interns from Community College of Philadelphia
- Outreach – NanoDay, Singh Center Annual meeting support
- Knowledge dissemination: Publication in Scholarly Commons or journals

Outcomes (as of Oct 2024)

- 54 out of 116: Ph.D. and other professional degrees in the USA, Europe and Asia
- Another 62 GSF: Engineers, managers, and entrepreneurs at companies such as Micron, Global Foundries, ASML, Analog Devices, KLA, Lam Research, Applied Materials, Boeing, Raytheon Technology, Rystad Energy, Tesla, Amazon and multiple startups.

National Nanotechnology Coordinated Infrastructure NSF

SINGH Center for Nanotechnology
Mid-Atlantic Nanotechnology Hub

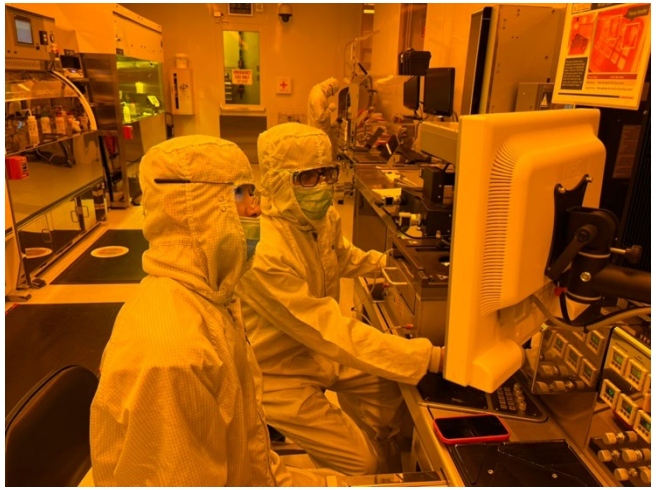
Penn

Community College of Philadelphia

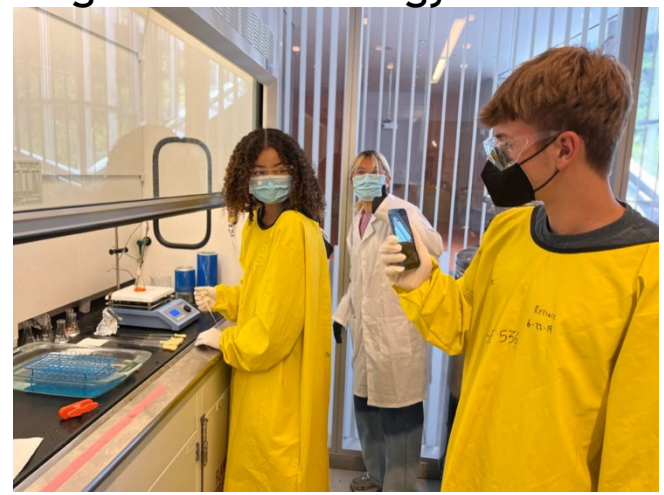
Graduate Student Fellowship Program – Workforce Development for Master's Students

The GSF Team

TAing Nanotechnology Courses

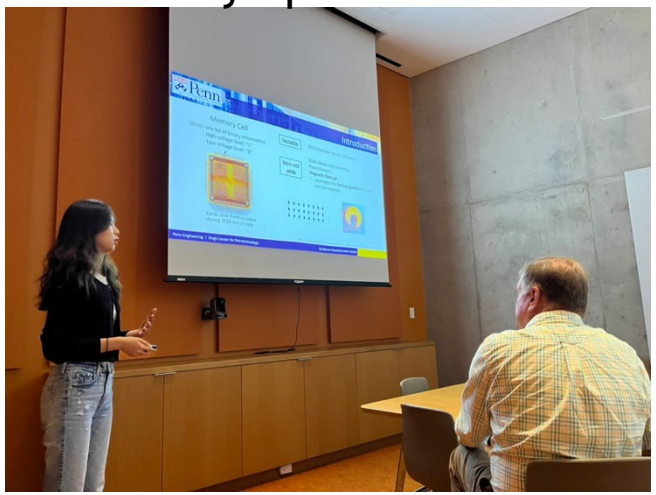


TAing Nanotechnology Courses



Mentoring Community College Interns

Symposia



Knowledge Dissemination

Journal of the Society for Information Display — SID

SPECIAL SECTION PAPER | Full Access

A fun and educative way for students to learn the nanofabrication through hands-on processing: Microletters

Francisco Saldana Fernandez, David J. Jones, Gyuseok L. Kim

First published: 13 May 2022 | https://doi.org/10.1002/jsid.1134

Check for full text

Funding information: National Science Foundation, Grant/Award Number: NNCI-2025608

National Nanotechnology Coordinated Infrastructure — NSF

SINGH Center for Nanotechnology

Mid-Atlantic Nanotechnology Hub

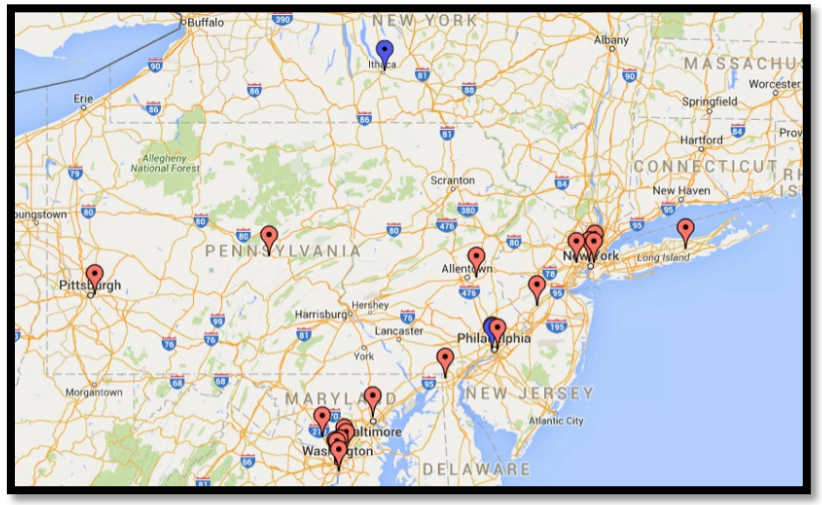
Penn

Community College of Philadelphia

Establishing Convening Opportunities for Nanotech

Mid-Atlantic Cleanroom Managers Meeting

- Conceived by MANTH Staff, the first two semi-annual meetings were hosted at Penn with the goal to disseminate knowledge, share best laboratory practices and provide a framework for equipment sharing within the Mid-Atlantic region.



Meeting for Advanced Electron Beam Lithography

▪ 2.3.3 → Meeting for Advanced Electron Beam Lithography – MAEBL¶

Created and organized by MANTH Staff, over 60 registered for the first MAEBL conference at MANTH on April 19, 2017 to discuss best practices, computational efforts and the state-of-the art techniques for fine feature patterning in electron beam lithography. The goal of the meeting was to connect active novice to experienced EBL tool owners and users in order to openly exchange practical and directly applicable EBL knowledge in an open forum format. This one-day program has been held annually since.¶

The 2nd MAEBL was held again at the University of Pennsylvania Singh Center for Nanotechnology on April 23, 2018.¶

The 3rd annual Meeting for Advanced Electron Beam Lithography (MAEBL) will be hosted by The Ohio State University on Wednesday, April

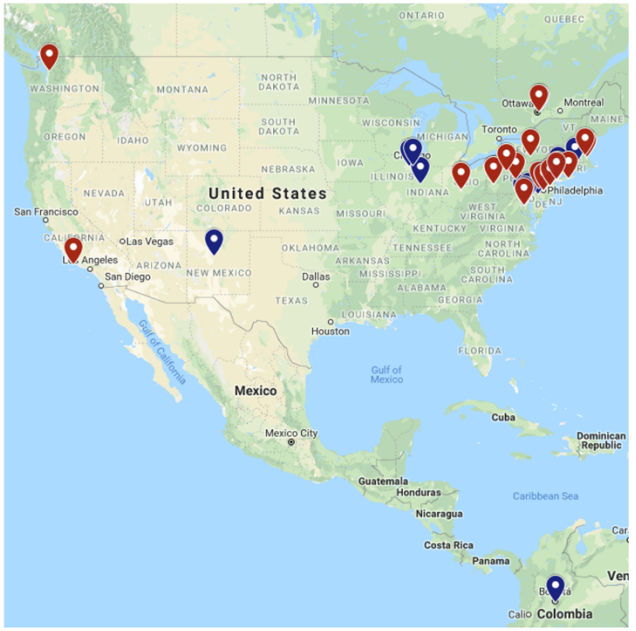


Figure 5. A map depicting the homes of attendees of the 2017 (blue pins) and 2018 (red) MAEBL meetings.¶

From 2017 Site Visit

From 2019 Site Report

National Nanotechnology Coordinated Infrastructure

NSF

SINGH Center for Nanotechnology

Mid-Atlantic Nanotechnology Hub

Penn

Community College of Philadelphia

MAEBL

MEETING FOR ADVANCED E-BEAM LITHOGRAPHY

Platinum Charters: RAITH, GenISys, Beamfox, STS ELIONIX, CLEANROOM LABWARE, MEO ENGINEERING
Gold Charter: ALLRESIST
Silver Charter: DisChem
Charter: JEOL, ZEON
Silver Sponsor: TESCAN

Established 501(c)(3) Public Charity in 2019 — www.maebl.org

- Sustained through registrations and sponsorships
- Engagement Focused for the E-Beam Lithography Community
- Online and In-Person Meetings

MAEBL Board of Directors

Gerald Lopez
MAEBL Board Chair & Co-Founder
University of Pennsylvania
Singh Center for Nanotechnology

Aimee Bross Price
MAEBL Co-Founder
The Ohio State University
Nanotech West Lab

Justin Wirth
MAEBL President
Purdue University
Birck Nanotechnology Center

Guy DeRose
MAEBL Vice President
California Institute of Technology
Kavli Nanoscience Institute

Mason Risley
MAEBL Secretary
Sandia National Laboratories

Allison Dove
MAEBL Technology Officer
University of California Berkeley
Marvell Nanofabrication Laboratory

Mark Mondol
MAEBL Board Member
Massachusetts Institute of Technology
MIT.nano

Cecilia Fasano
MAEBL Student Ambassador
University of Iowa

2024 Statistics

126 attendees
51 In-Person
75 Online
25 Students

78 organizations
92 Academic
15 Gov't
19 Industry

12 countries
87 USA
17 Canada
9 Australia
3 Great Britan
3 China
1 Switzerland
1 India
1 Saudi Arabia
1 Belgium
1 France
1 Denmark
1 Germany

Timeline

- 2017 — Penn, SINGH
- 2018 — Penn, SINGH
- 2019 — The Ohio State University, Institute for Materials Research
- 2020 — ONLINE
- 2021 — Penn, SINGH
- 2022 — Caltech, The Kavli Nanoscience Institute
- 2023 — The University of Chicago, The University of Chicago Pritzker School of Molecular Engineering
- 2024 — Georgia Tech, Institute for Matter and Systems
- 2025 — Carnegie Mellon University

International Travel Awards

MAEBL 2022 Travel Award Recipient
Michael Stuiber, Ph.D.
Melbourne Center for Nanofabrication
Victoria Node of the Australian National Fabrication Facility (ANFF)

MAEBL 2023 Travel Award Recipient
Venkatchalam P
Indian Institute of Science
Center for Nanoscience and Engineering

MAEBL 2024 Travel Award Recipient
Elliot Cheng, Ph.D.
University of Queensland
Centre for Microscopy and Microanalysis

MAEBL 2024 at Georgia Tech

Knowledge Exchange

slack
LinkedIn
FabuBlox

National Nanotechnology Coordinated Infrastructure
NSF
SINGH Center for Nanotechnology
Mid-Atlantic Nanotechnology Hub
Penn
Community College of Philadelphia

MANTH Seed Grants: Economic and Innovation Impact

- Since the beginning of the NNCI program, over **70** small companies and startups have utilized MANTH to create new nanotech products and services.
- To date (Year 8), over a third of our small companies have received external support tying our overall small company engagement to over **$85M** of funding, of which more than 40% is attributed to SBIR/STTR grants.

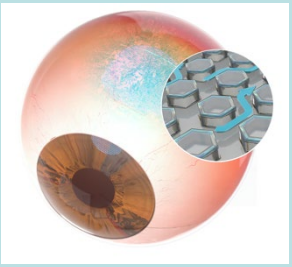
	2015	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
CrowdFund	$ -	$ -	$ -	$ -	$ 1,070	$ -	$ -	$ -	$ -	$ 1,070
Grant	$ -	$ -	$ -	$ -	$ -	$ 15	$ -	$ 221	$ 100	$ 336
In-Kind	$ -	$ -	$ -	$ -	$ -	$ -	$ 6	$ -	$ 330	$ 336
Other	$ -	$ -	$ -	$ -	$ -	$ 260	$ -	$ -	$ -	$ 260
SBIR	$ 300	$ 3,075	$ 681	$ 1,291	$ 4,861	$ 5,508	$ 11,687	$ 5,567	$ 3,372	$ 37,238
Seed	$ -	$ -	$ -	$ -	$ -	$ 755	$ 1,488	$ -	$ -	$ 2,243
Series A	$ -	$ -	$ -	$ 6,000	$ 8,000	$ -	$ -	$ -	$ -	$ 14,000
Series B	$ -	$ -	$ -	$ -	$ -	$ -	$ 20,500	$ -	$ -	$ 20,500
STTR	$ -	$ 233	$ 223	$ -	$ -	$ 420	$ 840	$ -	$ -	$ 1,716
VC	$ -	$ -	$ -	$ 1,250	$ -	$ -	$ -	$ 4,060	$ 1,000	$ 6,310
Grand Total	$ 300	$ 3,308	$ 904	$ 8,541	$ 13,931	$ 6,957	$ 34,522	$ 9,998	$ 4,802	**$ 85,297**

Graduate Student Fellows

Interns

Outreach

Convening Communities



Avisi Technologies – Using Nanotechnology to Treat Glaucoma: https://avisitech.com

Entrepreneurial Development

National Nanotechnology Coordinated Infrastructure

NSF

SINGH Center for Nanotechnology

Mid-Atlantic Nanotechnology Hub

Penn

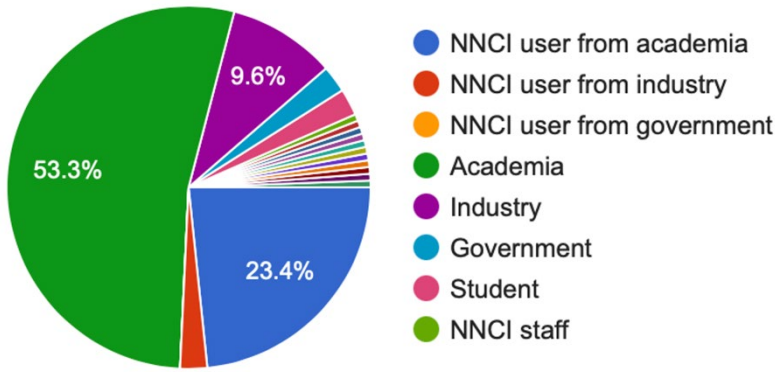
Community College of Philadelphia

NNCI's Research Communities - A Perspective from the Nano-IoT RC

Original RC concept

- Research Communities (RCs) are subsets of the 16 NNCI sites that convene to advance focused research topics within nanotechnology
- Annual RC symposia would be used to disseminate best practices and emerging trends; symposium participants would then return to their home institutions to disseminate information
- Different RCs might develop different models

Data from 2021 Nano-IoT RC Symposium
(160 unique registrants)



What worked?

- RCs can excite interest in these fields and bring together those who may not meet at other nanotech-centric conferences
- Inform those who operate NNCI facilities to understand capabilities of others
- Identifying emerging trends in nanotechnology
- Zoom/virtual symposia enhanced participation in many cases – and it worked for the information dissemination theme of RCs. Not clear if it will work as well for other RC functions.

What didn't work?

- Logistics: Hard to find time to meet that works for all sites (scheduling RC meetings to coincide with NNCI Annual Meetings or other conferences may be worth considering)
- Local site dissemination could be improved

What are suggestions that a future network might implement to support national priority research topics?

- Logistical support and staff development – engaged and informed staff improve conditions for users
- AI enhancement – what are the emerging trends in nanotechnology, and how can we cover/sunset them with RCs as appropriate?