

A large, modern, white building with a curved facade and numerous large glass windows. The building is surrounded by a landscaped area with green grass, trees, and a paved walkway. The sky is blue with scattered white clouds. The building has several tall, cylindrical chimneys or exhaust stacks on its roof.

Cornell NanoScale Science & Technology Facility

NNCI ANNUAL CONFERENCE

October 26-27, 2023

CNF: Cornell Nanoscale Facility

Who are we?



Prof. Judy Cha
PI, Director



Ron Olson
Director of Operations



Lynn Rathbun, Ph.D.
Laboratory Manager

- **Prof. Judy Cha named 9th Director of the CNF**
- World-class open user facility for micro- and nanofabrication to assist users from across the country and around the world
- Projects range from pure university research to product development for small and large companies
- Added new capabilities to CNF in 2023 through acquisitions, updates and partnerships
- New York State Nanofabrication Network

Addressing NSF's 10 Big Ideas on Data Revolution, Quantum Leap, Convergence, Rules of Life, Future of Work, ...

CNF: STAFF

Innovators and Expertise

Faculty Director



Lab Management



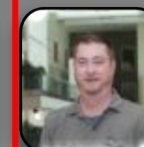
Ph.D. User Support Staff



Admin



Process Engineering & User Support (B.S./M.S.)



IT Staff



Technicians



Nanooze



Work diligently to serve and address the needs of the broad user community

CNF: Facilities

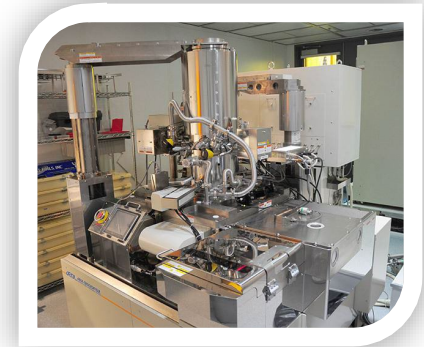
Start to Finish Device Fabrication

Advanced Lithography Suite

- JEOL 9500 and JEOL 6300
- 2 UV Steppers (i-line and g-line)
- Contact Lithography (x3)
- Nanoscribe 3D printer
- ASML 300C Deep UV Stepper (248 nm)
- Mask Fabrication (x2)
- Nanoimprint
- Direct Laser Writing

Broad Process Support / Test and Characterization / Backend Processing

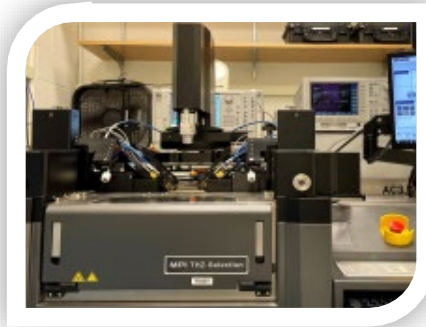
- 20 dry etch chambers
 - Deep Silicon Etchers
 - ALE, RIE and ICP RIE
 - Vapor HF and XeF2
 - Ion Milling
 - Ashing and descum
 - ALD x2, PECVD x2
 - 11 CVD tubes
 - 10 Atmospheric tubes
 - 8 Advanced evaporation and sputtering
 - AlN sputtering
 - Electron Microscopy
 - Optical Microscopy
 - **Electrical/(HFTL)**
 - Optical
 - Profilometry
 - Microfluidic
- Packaging, Backend and support tools
 - Software and Computation
 - **3D Fabrication and 3D Imaging (partnership BIOTech and Mech Eng)**
 - Dedicated facilities for microfluidics and soft lithography
 - **Ability to process a very wide range of heterogeneous materials without cross contamination as well as different wafer sizes – (pieces up to 200 mm)**



CNF: New Equipment and Capabilities

Terahertz Probe Station

- Anritsu ME7838G Vector Network Analyzers, 70 kHz to 220 GHz, single sweep Tool control
- MPI 2000-IFE/THz 8" Automated Probe Station with 1- μ m precision



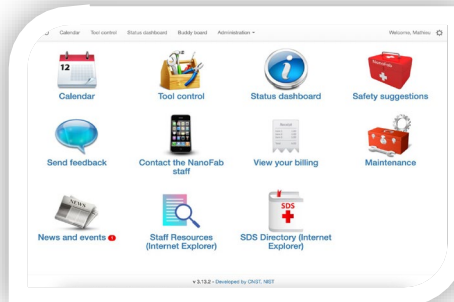
AJA UHV Multi-Technique Deposition

- Superconducting films for quantum applications
- Con-Focal and Direct Magnetron Sputtering Sources
- UHV Linear E-beam Source and In-situ crucible exchange
- **Spring 2024**



NEMO web application

- Equipment scheduling
- Tool control
- Access control
- Interlock integration
- Reporting
- Billing
- Data collection
- (Coral replacement)



Furnace tubes reconfigured

- LPCVD SiC
- High temperature LPCVD SiNx for III-V materials



3D Virtual Cleanroom Experience

<https://cornellcnf.link/virtual>

CNF: ECONOMIC DEVELOPMENT

CNF is a powerful engine of Economic Development

- **143 different companies** (107 small/startup and 36 large) have used CNF for research/prototyping under NNCI
- **17 new startups** (see logos)
- Partnership with two Cornell business incubators:
 - **Praxis:** Engineering and Physical Sciences Business Incubator, co-located in Duffield Hall
 - **The McGovern Center:** Life Sciences business incubator at Cornell

WHITE LIGHT POWER INC



Kanvas Biosciences
The Microbe Imaging Company



ODYSSEY SEMI



INSO BIO



CyteQuest®

JR2J, LLC



What successful examples of programs, activities, and relationships in the current NNCI could be adapted or expanded for multiple sites in a future network?

CNF: Programs, Activities, Relationships

Education Outreach → Workforce development

- Micron “Chip Camps”
- 4H partnership – with NNCI sites
- New Visions Engineering – college bound
- Expanding Your Horizons – middle school girls
- REU and iREU program for NNCI (IRES proposal)
- Nanooze K-12 Magazine for NNCI
- Nano Mini Exhibit at the Local ScienCenter
- Visits/Tours for K-12 , First Lego, Kangaroo Math
- CNF Ambassadors

DEIA

- Partnership with Morgan State University
- NNCI diversity sub-committee
- Diversity Programs in Engineering
- REU program
- Nellie Whetten Award to women scientists

Regional Impact

- **NY State Nanotechnology Network (NNN)**
- Partnerships with Industry and academia, Community colleges to develop Micro/Nano training programs
- Tompkins County, Workforce Development Board of Directors
- ME Commons NORDTECH



Education outreach → Workforce Development

- Micro-credentials offered through local community college (TC3)
- Micro/Nano training programs -Partnering with local community colleges and local industry
- **Undergrad nanofabrication course (ECE 4360)**
- ATLAS TST BOCES New Visions Engineering
- CNF Fellows and Ambassadors
- TCN short course

Facility Operation

- Weekly technical sessions
- Free consulting and supplies
- Quick User Onboarding
- Foundry partners – Fraunhofer and NY CREATES
- Low-cost accommodation for external users

Economic Development

- Praxis startup incubator
- Growing startup community
- Community of contractors

Network Activities

- Staff exchanges, surplus equipment exchange, workshops, working groups, research communities and subcommittees – with NNCI sites
- Regional network working group

Relationships & Collaborations:

Regional Networks /Regional Impact

- **Fall of 2020 Initial workshop-** brought together NYS industry, and universities to discuss
 - Sharing resources,
 - Job creation and workforce training
 - How we as an alliance can bring funding and support NYS
- **Spring of 2021 focused groups determine next steps**
 - Workforce training, startup/early-stage company, **NNN Road map**

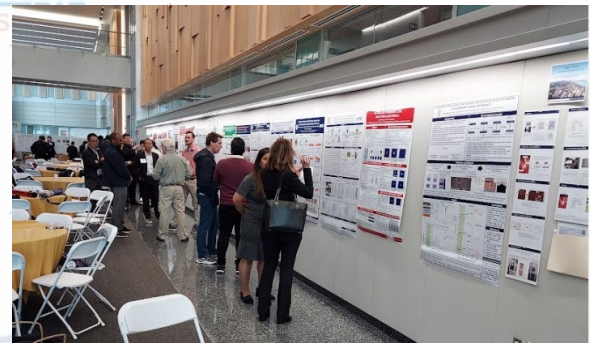


NNN Student Showcase and Career Fairs - Focused on connecting NYS undergraduate and graduate students with industry partners

An effective method for joining regional universities and companies while promoting our students and their accomplishments



- **May 19, 2022 @ Cornell University**
 - "Bridging the Workforce Gap"
 - 88 total participants (64 Academic, 21 Industry, 3 Government)
- **April 25, 2023 @ University at Albany SUNY (coordinated by CNF)**
 - "Advances in the Semiconductor Industry"
 - 143 total participants (97 Academic, 44 Corporate, 2 Government)
- **September 6-7, 2023 @ Albany Nanotech Complex (coordinated by Binghamton)**
 - Electronics Packaging Symposium
 - 250 total participants (81 Academic, 135 Corporate, 11 Government, 23 undeclared)



Relationships & Collaborations:

Undergraduates and Undergraduate Institutions

Research Experience for Undergraduates

- An effective cross-network program that should be expanded and supported by the network
- At CNF, Supported from the **CNF Cooperative Agreement**
 - Eight Participants in 2023
 - **327 participants since 1990**
- Longitudinal tracking of NNUN/NNIN REU participants 1997-2015
 - Education outcomes
 - **54% of all participants have gone on to pursue a Ph.D.**
 - 50% Ph.D. (women)
 - 40% Ph.D. (URMs)
 - **more than 90% of participants remain in a scientific career**
- The NNCI REU Convocation is a unique REU experience that has great impact on the young researchers



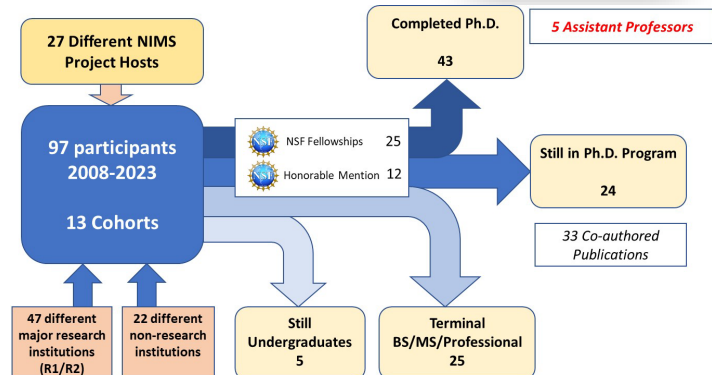
Relationships & Collaborations: *International*

International REU-Japan

- Conducted by CNF on behalf of NNCI
 - Draws participants from prior-year NNCI REU Program
- Currently funded via **International Research Experience for Students award** to CNF from NSF –OISE
- A **10-week summer research program** between NNCI and the National Institute for Materials Science in Japan
- Formative experience in developing intercultural research skills necessary in the 21st century-Developing **“Globally Aware Scientists”**
- 91 participants in IREU since 2008
 - Additional 6 participants in the NNCI-affiliated Global quantum leap IRTE
 - 43 Ph.D.s** (5 Assist. Profs.), **24 still in graduate school**, 25 NSF-GFP awards
- Significant quantitative increase in “Cultural Intelligence” as measured by a commercial academically-validated assessment instrument



5 participants in 2022
5 participants in 2023



Relationships / Collaborations

HBCUs

Morgan State University

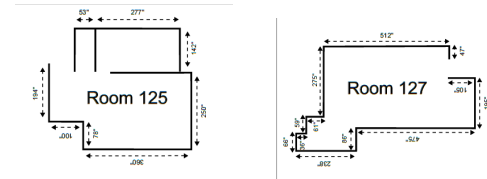
MSU is an HBCU, who produces the highest number of EE students annually and a drive away from the CNF

CNF - Morgan State Fellows

- Accept selected **MSU students into CNF REU** program
 - Financial **support from CU College of Engineering**
 - One student in summer 2022
 - **Two students in Summer 2023**
 - Students and faculty take part in REU convocation and speak at CNF annual meeting

CNF-MSU working relationship

- **Provided advice on cleanroom design and processing equipment**
 - Train staff as they are hired on equipment operations
- Create future nanoscience leaders**
- Return to MSU and carry out advanced research



Relationships & Collaborations

Regional Industry

Micron Workforce Development

- Northeast University Semiconductor Network
 - A partnership for collectively developing the next generation of the U.S. semiconductor workforce.
- Micron Chip Camps
 - Introduce middle school students to the concept of microtechnology, and to the possibility of careers in the field.
 - In 2023 three separate camps with > 100 students each are planned at CNF for Syracuse regional school districts. April 5, June 27, July 18
- CNF, Morgan State, and University of Washington informal Micron consortium
 - Collaboration specific to cleanroom education and student experiential opportunities
 - All three institutions will be key to the supporting the Idaho and NY expansions.



Relationships & Collaborations

Community Colleges/Workforce

Workforce Development with TC3



Micro-Credential in Semiconductor Fields

Fundamental knowledge required to work safely and effectively in the semiconductor cleanroom environment as well as other high tech scientific facilities.

Based on existing CNF training materials/programs

Cleanroom Orientation and Safety MNT 100

- Protocols for working in a cleanroom environment.
- Understanding why micro and nanofabrication is performed in a cleanroom.
- Chemical safety practices.

Technology and Characterization at the Nanoscale MNT 101

- Fundamental concepts of photolithography.
- Key concepts of wet and dry etching.
- Fundamentals of Imaging.
- Concepts of metrology at the micro-nanoscale.

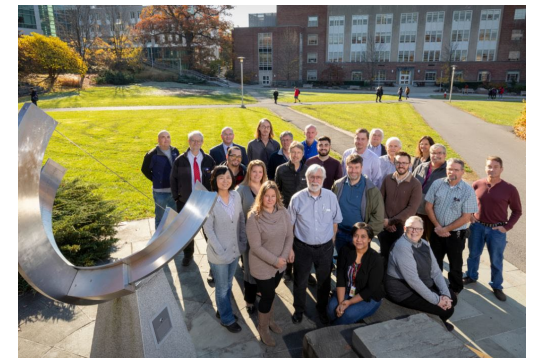
- CNF is supporting TC3 in the development of further micro-credentials as well as a track with A.A.S degree program
- New York State Funding Opportunities



Relationships & Collaborations

High Schools and Vocational Schools

- **ATLAS- (Advanced Training for Labor Acceleration in Semiconductors)**
 - Provide students with comprehensive in person/hands on training in key areas of cleanroom semiconductor environment.
 - TST BOCES New Visions Engineering: 15 High school seniors on engineering path
- Developing relationships with Regional vocational schools for enrichment of relevant trade courses via demonstrations and field trips
 - Robotics / Mechatronics
 - Ultra high purity gas line welding



Activities and Programs

User Support

High level of user support is what distinguishes NNCI sites from dozens of other facilities. NNCI should continue to share resources and best practices

- **Weekly Tech Sessions -**
 - We host an open technical session to discuss process flows and devices/structures with the CNF technical staff.
 - Leverage the knowledge and experience of the CNF technical staff
- **NNCI Technical Working Groups**
 - Expand activity and content

