

2024-2025 CNF Research Accomplishments

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PHOTOGRAPHY CREDITS

This year's front cover image is from the report "Fabrication of 2D Graphene Devices for Low Temperature Transport Measurement"; CNF Project 3125-23, Principal Investigator: Kenji Yasuda; Users: Benjamin Byrd, Lujin Min, and Zhen Yang; Affiliation: Department of Physics, Cornell University — and was used with their permission. The full report starts on page 168.

This year's back cover image is from the report "Fabrication of Fluxonium-Like Qubits"; CNF Project 3125-23, Principal Investigator: Ivan Pechenezhskiy; Users: Benjamin Byrd, and Kesavan Manivannan; Affiliation: Department of Physics, Syracuse University — and was used with their permission. The full report starts on page 156.

COMMENTS, FEEDBACK, AND SUGGESTIONS ARE ALWAYS WELCOME.

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2024-2025 CNF Research Accomplishments

DIRECTORS' INTRODUCTION

The Cornell NanoScale Science and Technology Facility (CNF) takes pride in presenting the research achievements of our users and research groups who utilize the extensive array of resources provided by the CNF. We appreciate all the contributors who provided input to this publication. The Research Accomplishments showcases excellence in research while underscoring the diverse array of cutting-edge advancements spanning various fields of science and technology. Together with the spotlight on 104 featured research reports, CNF-related patents, presentations, and publications (totaling over 400 in 2024) have been included.

NNCI

For the last 10 years CNF has been a member of the National Nanotechnology Coordinated Infrastructure (NNCI), supported by the National Science Foundation (NSF). Cornell was one of 16 collaborative sites within this national user consortium, dedicated to providing start-to-finish fabrication and characterization capabilities to a diverse range of users from both academia and industry. As of August 31, 2025, funding from this NSF program ended. We have been granted a no-cost extension from September 1, 2025 to August 31, 2026 to facilitate the orderly wind-down of our programs. Earlier this year the CNF submitted "The Year 10 Annual Report" and a final report will be submitted after September 2026. We gratefully acknowledge the steadfast support from the NSF over the years, and are looking ahead to the future and the next nanotechnology infrastructure program. In the meantime, we will continue to support the research activities of both Cornell and non-Cornell users.

NORDTECH

In 2023, CNF received \$8.2 million to expand fabrication capabilities through NORDTECH, one of eight Microelectronics (ME) Commons hubs selected by the Department of Defense (DOD) and supported by the CHIPS and Science Act. This funding is part of a \$2 billion initiative to enhance U.S. microelectronics development. CNF is a founding partner of the NORDTECH hub alongside IBM, University at Albany, NY CREATES, and RPI. This initial investment was

used to expand our capabilities in Quantum Science and Technology, Heterointegration, and 200mm wafer processing. These upgrades represent CNF's largest capital expansion since its inception, with numerous new tools and capabilities acquired, installed, or qualified over the past year (see Table 1). The ME Commons seeks to bolster U.S. microelectronics development and manufacturing in support of DOD mission priorities, particularly by promoting the "Lab to Fab" transition.

NEW TOOLS AND CAPABILITIES

New, more advanced capabilities are constantly being added at CNF to improve the user experience and enable new frontiers of research. Acquisitions of new tools of interest are based on consultation with the CNF user community, our User Committee, the Executive Committee, External Advisory Board, and Cornell faculty. The following equipment has been acquired over the past year and either is installed or being installed. Please visit our website <https://www.cnf.cornell.edu/equipment> for more information.

EDUCATION AND OUTREACH

CNF has a comprehensive education and workforce development effort that spans K through 12, post-secondary, professional, and public audiences. CNF views traditional education and outreach programs as critical pipeline for developing a skilled high-tech workforce. There has been an increased focus on workforce development brought about by programs such as the CHIPS & Science Act and the DOD ME Commons programs. This past year CNF reached over 9,000 individuals through 139 events, offering hands on learning and engagement opportunities to build awareness and interest in nanotechnology. CNF programs include: Nanooze, a kid-friendly science magazine distributed to over 100,000 readers annually; our biannual "Technology and Characterization at the Nanoscale" (TCN), a three-day course that covers core nanotechnologies taught by CNF staff; our New Visions Engineering Accelerated Training for Labor Advancement in Semiconductors (ATLAS) program in collaboration with Tompkins Seneca Tioga (TST) Boards of Cooperative Educational

Recent Capital Equipment Acquisitions			
200 mm capable - Zeiss GeminiSEM 560 <i>Funded by ME Commons</i>	Plasma-Therm Plasma Dicing System <i>Funded by ME Commons</i>	Osiris- Temporary Bonding and Debonding <i>Funded by ME Commons</i>	Logitech Orbis 200 mm CMP Upgrade Kit <i>Funded by ME Commons</i>
AJA UHV Sputter Deposition- Quantum applications <i>Funded by ME Commons</i>	YES Polyimide Cure Oven <i>Funded by ME Commons</i>	Nano- Master SWC-4000 Brush Cleaner <i>Funded by ME Commons</i>	Heidelberg MLA150- Maskless lithography <i>Funded by ME Commons</i>
Angstrom UHV E-beam Evap - superconducting materials and JJs <i>Funded by ME Commons</i>	KLA SPTS E2 XeF2 Etcher <i>Funded by ME Commons</i>	REYNOLDSTECH Custom Electroplating <i>Funded by ME Commons</i>	Oxford ASP ALD - superconducting materials and nitride materials <i>Funded by ME Commons</i>
SEKI Microwave Plasma CVD - quantum grade diamond <i>Funded by ME Commons</i>	Oxford PlasmaPro 100 Cobra 300 - oxide and diamond etching <i>Funded by ME Commons</i>	Disco Wafer Back Grinding and DI H2O Recycling Unit <i>Funded by ME Commons</i>	Keyence Digital Microscope <i>Funded by ME Commons</i>
AJA Q Deposition system - for superconducting materials and devices	KLA Filmetrics R50-200 - Resistivity	Oxford Cobra ALE- for quantum device etching	TPT Semi-Automatic Thermosonic Wire Bonder

Table 1: Tools/capabilities that have been acquired or installed/qualified over the past year at the CNF.

Services (BOCES), which provides high school students access to the CNF cleanroom; Micron “Chip Camps” that provide middle school students with cleanroom and nanotechnology experiences; and a High Purity Welding program that introduces vocational students to high tech career paths, in partnership with BOCES. The CNF also supported internships and research experience for undergraduates (REUs). CNF staff members played key mentoring roles, ensuring the interns and REUs gained valuable skills and experience to support their career development. CNF also continued its annual outreach events, including Tompkins County Expanding Your Horizons, 4-H Career Explorations, New York State Fair, alumni reunion tours, STEM EXPO (Junior First Lego League 2.0), Kangaroo Math, and various science classroom visits.

CNF has been working with Tompkins-Cortland Community College (TC3) to establish a Micro-Nanotechnology (MNT) concentration within their existing A.A.S. degree program. This past year CNF staff have assisted with the procurement of vacuum and metrology equipment that will enable additional micro-credentials within the existing A.A.S degree programs at TC3. In addition, CNF and TC3 also collaborate in the NSF funded Microfabrication and Nanotechnology Certificate Program (MNCP) for veterans in partnership with Penn State University, providing veterans with

pathways into the semiconductor industry.

Our most compelling education and workforce development activity is our digital learning and virtual reality (VR) educational initiative. We are working with e-Cornell to create digital classroom content focused on the core principles of semiconductor processing. And over the last two years the CNF has been working with the staff at the Cornell Center for Teaching Innovation, to develop a series of short (~20 minutes) VR cleanroom training experiences which bring learners directly into the CNF using high resolution, immersive 360-degree video with embedded interactive content and quizzes. This effort, led by CNF Workforce Development Program Manager Tom Pennell, will ultimately produce 20 – 30 modules that create a unique, immersive learning experience accessible from anywhere, expanding Cornell’s educational reach far beyond the walls of the CNF cleanroom facility. To date, CNF has had over 1,600 users of our VR educational content with over 1,000 hours of combined time spent in VR. The VR modules were also used as supplementary materials in Cornell engineering courses, such as MSE5410/ECE4360 “Nanofabrication and Characterization of Electronics.”

STAFF AWARDS

Congratulations to CNF staff members **Stacy Clementson** and **Jeremy Clark** who were honored with a national award from the NNCI. Annually, the NNCI acknowledges the efforts of NNCI staff who provide exceptional service and support to network users in the categories of Technical Staff, Education and Outreach, and User Support. This past year Stacy was recognized by the NNCI in the **User Support** category and Jeremy Clark was honored with the Technical Staff award. Both received plaques, acknowledgement at the NNCI Annual Conference in Louisville and are recognized on the NNCI website and in the NNCI yearly report to the NSF. We are proud of their efforts and contributions.

The exceptional staff at the CNF have been consistently recognized with NNCI Outstanding Staff Member Awards. Past award recipients include Chris Alpha – Technical Staff (2018), Tom Pennell – Education and Outreach (2020), Phil infante – Technical staff (2021) and Mike Skvarla – User Support (2021), Melanie -Clair Mallison – Education and Outreach (2022) and Aaron Windsor (2022) – User Support, and Karis Musa – User Support (2023).

Congratulations to Tom Pennell who was awarded an Honorary EPICC award in the category of “Purpose” by the College of Engineering for his impact on workforce development activities. In 2024 Tom was also honored with the Distinguished Alumni Award from TC3. This award recognizes TC3 graduates who have made a meaningful impact through their careers and service to the community.

STAFF UPDATES

Departures

Melanie-Claire Mallison retired in September 2024 after 28 years at CNF. Melanie was responsible for the CNF REU program, the CNF Research Accomplishments, newsletters, corporate sponsors, visitors, web site, and other forms of external communications.

Alan Bleier retired in January 2025 after 24 years at CNF. Alan supported CNF users for both scanning electron microscopy and electron beam lithography.

In June 2025 Roberto Panepucci left CNF to become Managing Director of the Microelectronics Research Center at the University of Texas at Austin.

In August 2025 Paul Pelletier who specialized in the installation of the NORDETCH equipment left CNF to start Northeast Orbital Welding, a startup business based in the Albany area.

Welcomes

In January 2025, Emma Carlo, a recent graduate from SUNY Oneonta with a degree in Communications, joined CNF as Student Program and Events Coordinator. In her role, she oversees the REU program, manages and updates CNF publications, website, and social media, and coordinates CNF events.

Philip Schneider joined CNF in February 2025. Phillip holds a B.S. degree in Nanoscale Engineering from SUNY Poly and an M.S. degree in Materials Science from SUNY Binghamton. He most recently served as a Metrology Engineer at Wolfsped in Marcy, NY. Philip supports both CNF’s metrology and Reactive Ion Etching technology.

Shilling Du, Ph.D joined CNF in April 2025 with a Ph.D. from Washington University in St. Louis. She has expertise in quantum devices and will largely support the new NORDTECH quantum deposition tools.

With your support, we look forward to the next nanotechnology infrastructure and continuing CNF’s role as one of the nation’s leading academic nanofabrication facilities, providing world class facilities and technical expertise to our user community. We appreciate all the contributors who provided input to this publication, which can also be found online at https://www.cnf.cornell.edu/publications/research_accomplishments We welcome your comments, questions and suggestions. Use the link below to share your feedback with us: <https://cornellcnf.link/feedback>

Judy Cha, Lester B. Knight Director

Allison Godwin, Associate Director

Ron Olson, Director of Operations

Lynn Rathbun, Laboratory Manager