MIT.nano

The mission of MIT.nano is to Build a Better World by fostering education, innovation, and research on nanoscale phenomena, materials, devices, and systems.

MIT.nano's shared experimental facilities, primarily located in the Lisa T. Su Building at MIT, are a central resource for the entire campus. Since opening to users in 2019, the 100,000 square feet of active lab spaces have built up capabilities for nanoscale patterning; extensive film and device processing from pieces to 8" wafers of silicon, compound semiconductors, 2-D films, nanotubes/nanowires, semiconductive oxides; as well as sheet area additive processing over 12" rigid or flexible substrates of nanostructured solids. Extensive materials characterization facilities exist both within and outside of cleanrooms, with demonstrated imaging at sub-atomic resolution down to 60 picometers.

Delivering Impact

The MIT community is utilizing the shared central facilities of MIT.nano to:

- Teach students the fundamentals of quantum mechanics and nanoscale science—hands-on (MIT News, March 30, 2023)
- Design compression-resistant nanoscale materials (MIT News, December 18, 2022)
- Fabricate biologically inspired nanometer-scale resistive-memory devices for powering fast, energy-efficient deep learning algorithms (MIT News, July 28, 2022)
- Shed light on how molecular machines help break down proteins within a cell (MIT News, November 1, 2022)
- Integrate two-dimensional materials directly onto silicon circuits for denser and more powerful chips (MIT News, April 27, 2023)
- identify ways to significantly increase lifetimes of fuel cells and other devices for more sustainable energy (MIT News, August 31, 2022)
- Capture and quantify the movements of dancers to illuminate what it means to be efficient or fatigued in other domains (MIT Spectrum, Spring 2023)
- Etch messages—in more than 64 languages from over 80 countries—onto a single wafer to carry into space (MIT News, May 8, 2023)

These are but a few examples of the value that MIT.nano has helped add to MIT over the past year. Many of these stories are captured in the 37 MIT News articles posted in FY2023 which reference MIT.nano,and are shared with over 4000 unique monthly visitors of MIT.nano website.

As we transition MIT.nano over the next few years from its startup phase to its steady state operation, we expect to deliver even more to our broad community, amplifying the research, education, and innovation on campus and beyond.

Growth of User Base

In FY2023, MIT.nano supported 850+ lab users from 250+ principal investigators (PIs), which included both internal MIT (students, postdocs, staff, faculty) as well as external academic and industry users. These numbers represents a 40% increase in our user base in just one year.

Approximately 720 internal users came from over 180 faculty and PI groups from across the Institute, primarily from the Schools of Engineering and Science, but also from the Schools of Architecture and Planning; Humanities, Arts, and Social Sciences; and the MIT Sloan School of Management. In addition, the over 130 external users (15% of our user base) came from 66 industry, startup, and academic organizations outside of MIT.

The DLCs represented in MIT.nano's user base included (list not exhaustive):

- *Departments/Programs:* Aeronautics and Astronautics, Architecture, Biological Engineering (BE), Biology, Brain & Cognitive Sciences (BCS), Chemical Engineering (ChemE), Chemistry, Civil and Environmental Engineering (CEE), Comparative Media Studies/Writing, Electrical Engineering and Computer Science (EECS), Global Studies and Languages, Materials Science and Engineering (DMSE), Mechanical Engineering (MechE), Nuclear Science and Engineering (NSE), Physics, Program in Art, Culture and Technology (ACT), Program in Media Arts and Sciences (MAS), Sloan School of Management, Urban Studies & Planning (DUSP)
- *Laboratories, Centers, Institutes, and Offices*: Computer Science and Artificial Intelligence Laboratory (CSAIL), DAPER Intercollegiate Sports, Institute for Medical Engineering and Science (IMES), Institute for Soldier Nanotechnologies (ISN), Kavli Institute for Astrophysics & Space Research, Koch Institute for Integrative Cancer Research (KI), Lincoln Laboratory (MIT LL), Materials Research Laboratory (MRL), McGovern Institute for Brain Research, Microsystems Technology Laboratories (MTL), Plasma Science and Fusion Center, Office of Government and Community Relations (OGCR), Research Laboratory of Electronics (RLE)

Serving Users: Research Support and User Training

In general, users are trained on proper operating procedures for their specific equipment needs and proceed to operate the tools/instruments as self-users. For more complex equipment, they may request staff-assisted use.

Below we highlight three specific areas targeted in FY2023 to improve user experience:

Streamlining the New User Sign-on Process

A significant concern raised by prospective users in previous years was that the process to become a user and start using the fab was too lengthy and cumbersome. We took several substantial steps towards streamlining the new user onboarding process, saving time for users as well as administrative and technical staff:

- Re-worked key trainings to be more time efficient and less dependent on staff commitments, as well as more effective for participant learning:
    - MIT.nano Emergency Preparedness: revamped from staff-led presentations with limited scheduling to a self-paced, comprehensive online course
    - Fab.nano Wet Chemical Processing: formerly a two-part staff-led training scheduled only bi-weekly, this has evolved into a set of short self-paced, online tutorial videos and readings followed by a single in-person classroom session available weekly that now includes an assessment of foundational knowledge
- Began consolidating application forms, training signups, and process submissions to the nanousers.mit.edu portal instead of being scattered across multiple sites.
- Began updating and re-organizing the nanousers.mit.edu site to make information easier to find and more relevant for users, work that will continue through FY2024.

Strengthening Communication to and from Users

In Fall 2022, with assistance from MIT Institutional Research, we invited all users to join a survey on user experiences and needs in order to improve operations and assist long-term planning. The quantitative survey indicated general satisfaction with MIT.nano equipment capabilities and staff performance across the user pool and identified wish lists of tools across MIT.nano facilities.

To help connect more easily with users and respond more quickly to questions and lab issues—large or small—we have made multiple channels available:

- General and tool-specific inquiry webforms,
- Dedicated email help addresses,
- Weekly office hours,
- Periodic topical mini-surveys,
- Web portal for anonymous comments/questions, and
- Weekly digest emails sent directly to users.

These efforts have contributed to an improved perception of staff responsiveness and have added to the development of a unified user community.

Bolstering a Culture of Safety with the Creation of Safety Circuits

MIT.nano launched the Safety Circuits program. During a Safety Circuit, MIT.nano staff dedicate at least one hour a week to making the rounds throughout the cleanroom with a keen eye towards facilitating safe work practices and good housekeeping. Spotlighted by MIT Environmental Health and Safety (EHS) during Lab Safety week, MIT.nano's Safety Circuits serve as a platform to promote best practices in the lab, increase communication and visibility of staff members, and promote safety as a shared responsibility.

Supporting Hands-on Education: Academic Class Support

MIT.nano staff continued to support multiple academic classes in AY2023, assisting with the development of new classes as well as providing class instruction time at no cost to the academic departments. Two classes that heavily utilize MIT.nano's toolsets (first introduced in AY2022 and described in last year's report) again gave students an experience not common at the undergraduate level – performing hands-on research inside a highly sophisticated cleanroom laboratory:

- *6.2540 Nanotechnology—Design from atoms to everything*, led by Assistant Professor Farnaz Niroui of Electrical Engineering and Computer Science together with Professors Rajeev Ram and Akintunde I. Akinwande of Electrical Engineering
- *6.A06 First.nano! – Fabricate your own solar cell in MIT.nano Cleanroom*, taught by Professor Jesus del Alamo of Electrical Engineering and MIT.nano Associate Director of User Services Dr. Jorg Scholvin

Other AY2023 undergraduate and graduate classes in the Schools of Engineering and Science which utilized MIT.nano tools and instruments to enhance students' experience beyond the classroom included 2.002 (MechE), 3.001, 3.074, 3.65, 3.201, 3.091, 3.17/37 (DMSE); 6.012, 6.2600J/3.155J (EECS); and 20.051 (BE), among others.

The School of Architecture class 4.373/4 ("Creating Art, Thinking Science"), which grew out of the 4.322/3 class described in last year's report, was taught by Lecturer Tobias Putrih of the Program for Art, Culture, and Technology in collaboration with MIT.nano director Vladimir Bulović. Embedding art students into a research lab environment, the class offered unique access to advanced MIT.nano facilities and ongoing research. Supported by an Alumni Class Fund grant, this year's class added a paid teaching assistant (TA) to guide the art students in hands-on nanofabrication and characterization processes. Notably, five additional science/engineering graduate students volunteered as TAs to participate in creating art work as well, demonstrating strong student interest in hybrid art/science offerings. The art work generated by the students in the class is displayed in the hallway galleries of MIT.nano, and has been recognized by art awards.

Supporting Young Faculty

Recognizing the need to support junior faculty whose research thrusts critically depend upon access to the types of experimental facilities in MIT.nano, the Young Faculty Awards grant awardees "nanoBucks" to enable more extensive use of the shared tools and instruments in the advancement of their research. In FY2023 six early career faculty were granted Young Faculty Awards:

- Associate Professor of Civil and Environmental Engineering Admir Masic
- Assistant Professor of Electrical Engineering and Computer Science Jelena Notaroš
- Assistant Professor of Chemical Engineering Ariel Furst
- Associate Professor of Electrical Engineering and Computer Science Kevin O'Brien
- Assistant Professor of Biology Seychelle Vos
- Associate Professor of Biology Joseph (Joey) Davis

These awards are made possible by funding from the MIT.nano Consortium membership.

Access to Partner Facilities and Collaborations

Fab.nano – MIT.nano continues to partner with MIT Lincoln Laboratory, enabling users to access an augmented set of processing capabilities in MIT LL's 200mm Prototyping Facility, the Microelectronics Laboratory (ML).

Characterization.nano – In addition to coordinating with the Materials Research Laboratory (MRL) on user onboarding and training on complementary equipment, MIT.nano regularly connected with other core facilities (Koch, ISN, and MRL) to enable instrumentation/capabilities coordination across campus. Several staff members are shared between facilities (spending between 10% and 50% time at MIT.nano), enhancing the exchange of resources and expertise.

MIT.nano also participates monthly in biological imaging facilities meetings with Koch Institute; Ragon Institute of MGH, MIT, and Harvard; and W. M. Keck Microscopy Facility at Whitehead Institute.

Immersion Lab – With the increase in human subject research (HSR) conducted in the Immersion Lab, this year we began monthly coordination meetings with the MIT Center for Clinical and Translational Research (CCTR). The complementary central facilities, with XR (extended reality) and clinical focus, respectively, are sharing physiological sensing equipment, resources, and topical knowledge as well as staff expertise to aid users in HSR.

Expansion Infrastructure and Toolsets

We continue to follow our established multi-step process for procurement and installation of tools in MIT.nano, with groups of tools aggregated into "Phases" to leverage professional resources and to enable financial benefits from economy of scale.

In FY2023 MIT.nano completed Phase 3 of our four-phase, tool installation approach—positioning new instruments inside the Building 12 MIT.nano facilities and relocating existing equipment from other MIT laboratories. Phase 4 commenced during FY2023 (scope development and schematic design) and will proceed through FY2024.

With the completion of Phase 3, 193 tools and instruments have been installed in MIT.nano.

Completed Moveout from Building 39 Prior to Decommissioning

In Phase 3, the team completed the five-year process of decommissioning the fabrication toolsets of Building 39 and transitioned all of the shared users to Building 12 facilities. By June 2023, all hazardous gas and liquid use associated with the former shared fabrication facilities in Building 39 had been transferred into Building 12, with significant energy savings realized with the subsequent facilities rampdown. We expect those spaces (former MTL fab and Nanostructures Laboratory shared facility) will be fully decommissioned and vacated at the end of December 2023.

In November 2022, the Applied Materials EPI Centura tool left the 5th floor of Building 39 via crane after 20 years of impact.

The move of all fab staff from offices located in Building 39 into Building 12 improved operational efficiency but also highlighted the need for additional staff offices in Building 12. Office renovation/reconfiguration design was carried out in spring 2023 and installation is expected to be completed during Phase 4 in FY2024.

New Tool Acquisition and Installations

Presently there are more than 190 tools and instruments available to users in MIT.nano, occupying ~65% of the available research area. Some of the recent instrument additions include:

- Ultra-fast sub-micron-resolution table-top 3-D printer (currently on demo from UpNano) that supports a range of photopolymer materials patternable by 2-photon polymerization
- High-speed electron beam lithography tool capable of patterning feature sizes down to 20 nm on a substrates ranging from small pieces up to 200-mm wafers
- An evaporative deposition system for quantum computing materials, stewarded by Professor William Oliver of Electrical Engineering and Computer Science and Physics
- An environmental transmission electron microscope (E-TEM) capable of spatial resolution down 0.078 nm and real-time imaging of dynamic processes under oxygen/hydrogen or humid atmospheres and heating or electrical biasing, an acquisition led by Professor Frances Ross of Materials Science and Engineering
- New plasma-enhanced atomic layer deposition (ALD) systems that can accept sample sizes ranging from small pieces up to 200-mm wafers, secured by Professor Tomas Palacios of Electrical Engineering and Computer Science

Following a demo period that proved significant user demand for non-destructive 3D X-ray microstructure imaging on campus, the Zeiss Xradia 620 Versa Micro-CT (described in last year's report) was acquired in collaboration with Professor John Hart of Mechanical Engineering and the MIT Center for Additive and Digital Advanced Production Technologies (APT).

Replicating this tool procurement model, in FY2023 we negotiated a year-long on-site demo of Oxford/WiTec confocal, hyperspectral Raman microsope. We are engaged with faculty to explore funding sources towards purchase of this instrument at the end of the demo period if the user base to sustain the tool is established.

Stewarding MIT.nano Space

Given the robust and ever-growing research activity of MIT, the on-campus laboratory research space is constrained. We recognize that Building 12 offers a high-performance laboratory spaces that needs be utilized as effectively as possible, leading us to continue to follow a clearly laid-out review and evaluation process for new shared tools, instruments, and Equipment Support Plans (ESPs) for privately-managed toolsets. User community surveys conducted in 2019 and 2022 have informed our prioritization for "wish list" tools and instruments (as an example, the acquisition of Versa Micro-CT fulfills a user need identified in the 2019 survey).

Upgrades to Building 12 Infrastructure and Safety Systems

Below we list three recent activities we undertook:

- In keeping with our commitment to environmental sustainability, in FY2023 we commissioned and started 2 abatement systems to reduce global warming impact and hazardousness of process gas emissions from cleanroom equipment and semiconductor tools of MIT.nano. Similar to energy conservation measures implemented in the cleanroom air handling (in which air recirculation rates are adjusted according to the user cleanroom occupancy sensed via motion and particle detectors), programmable logic controllers (PLCs) installed on the abatement systems enable them to adaptively switch between high/low/idle modes, only running reaction chambers at high power when process gases are needed.
- Over 10,000 hardwired sensors are installed throughout the building as part of the building monitoring systems. In FY2023 we began conducting a detailed sensor calibration effort with three-point evaluation to ensure accuracy, an effort not typically undertaken elsewhere on campus but good practice given the complexity and potential hazards in MIT.nano facilities.
- Annual staff safety and certification trainings (e.g., HAZWOPER, or Hazardous Waste Operations and Emergency Response training) are part of our safety culture and maintaining OSHA compliance. MIT.nano's Emergency Response Team (ERT) continues to develop and improve building emergency preparedness protocols and strengthen its coordination with DoF, MIT Environment, Health and Safety; MIT Police; and Cambridge Fire and Police.

Establishing Presence on Campus and Beyond

To cultivate awareness of MIT.nano and its purpose, we have taken significant steps to establish its presence on and off campus. These activities serve a strategic purpose to grow MIT.nano as a state-of-the-art research and education facility, to develop a close-knit and engaged community, to grow a broader ecosystem that connects to MIT.nano through the nurturing of the startup community, and engagement of established companies and organizations that can grow MIT's academic discoveries into impactful technologies.

Building User Community

Through its central location on campus, MIT.nano facility is a natural convening place for interdisciplinary research. Seminars, conferences, and gatherings for the researchers who use MIT.nano help bolster the exchange of ideas, knowledge, and the interconnectedness of our user community. We highlight a few from this past year:

- Microsystems Annual Research Conference 2023 (MARC) – Co-sponsored by MIT.nano and MTL, this annual January gathering of students, postdocs, faculty, and industry partners charts the future of microsystems and technology. The January 2023 MARC, the first in-person conference since 2020, gathered over 240 attendees and featured 100 student abstracts from 40 MIT research groups, the most groups ever represented at MARC. MIT.nano also supported the second annual Quantum Science and Engineering Annual Research Conference (QuARC) which was held immediately prior to MARC and explored the leading edge in quantum information science and engineering.

- Nano Explorations seminars – Launched in 2020, this year the monthly virtual seminars continued to feature MIT students and postdocs who work in nanoscience, nanotechnology, and advanced research fields. With a surprising reach beyond MIT, each seminar typically garnered 50 to 150 MIT attendees, alums, and industry partners.
- Tool Talks – Technical presentations sponsored by individual tool/instrument suppliers, Tool Talks offered users an opportunity both to be introduced to the latest transformative technological research innovations as well as to weigh in on new tools and capabilities MIT.nano ought to pursue to fulfill user needs. This year's 12 Tool Talks included a mix of virtual seminars and in-person hands-on demonstrations.
- IMMERSED seminar series – Organized by the Immersion Lab, the 7 virtual/hybrid seminars on immersive technologies, interactive experiences, and data included a mix of guest lectures, live demonstrations, and hands-on tutorials, with interest from both inside and outside MIT.

Engaging the Broader MIT Community

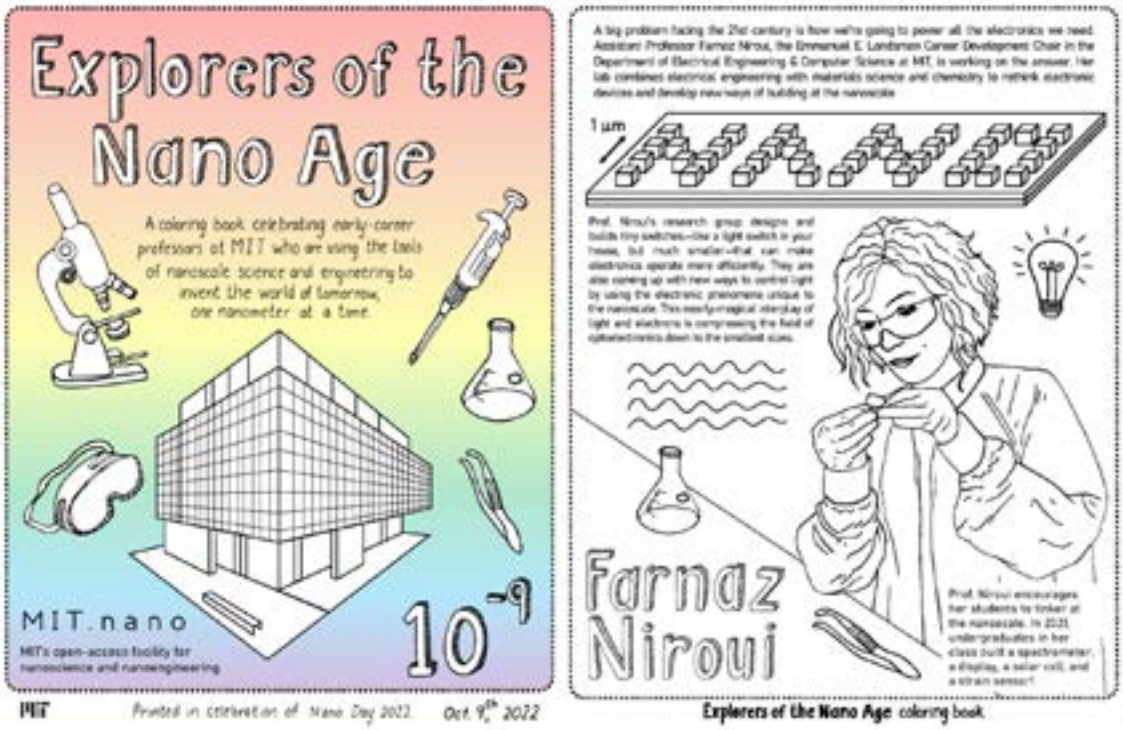
"Nano" is not a specific technology, nor does it belong to a particular discipline or industry, hence if brings a broad opportunity and appeal. In addition to engaging its users, in AY2023 MIT.nano sought to engage the broader MIT community through a range of activities, such as:

- MIT.nano Seminar Series – Organized by Professor Farnaz Niroui, the monthly seminars brought guest lecturers from across the spectrum of nanoscience and nanoengineering, in both academia and industry, from institutions across the US and around the world.
- Mildred S. Dresselhaus Lecture – The annual Dresselhaus Lecture in November, named in honor of Institute Professor Mildred "Millie" Dresselhaus, recognizes a significant figure in science and engineering whose leadership and impact echo Millie's life, accomplishments, and values. The 2022 lecture was delivered by Pablo Jarillo-Herrero, the Cecil and Ida Green Professor of Physics at MIT. Jarillo-Herrero's lecture introduced a combined in-person and virtual audience of over 200 to magic-angle graphene, the rise of moiré quantum matter, and what comes next, with a bit of inspiration from Millie.
- IAP classes – MIT.nano offered 5 IAP classes in January 2023 that over 300 students, alumni, and faculty/staff registered to participate in: hands-on fabrication in the cleanroom, an introduction to electron beam lithography, insights into XR biofeedback in sports training, a short course on immersive technologies for manufacturing and engineering, and workshops on science communication and STEAM outreach.
- Ambient Sensing – A half-day symposium presented on May 18, 2023 by the MIT.nano Immersion Lab, the fully virtual event featured MIT faculty and researchers from multiple disciplines and highlighted sensing technologies deployed everywhere from beneath the Earth's surface to high into the exosphere.

- Deep Tech Career Fair – An annual fall recruiting event, the MIT.nano-led multi-consortium career fair was held on October 4, 2022 and included companies from the MIT.nano Consortium, Microsystems Technology Laboratory Industrial Group, and Quantum Science & Engineering Consortium (QSEC).

Connecting Many Communities with MIT.nano Laboratories

The Lisa T. Su building's wide glass windows invite views into the laboratories and visually connect researchers inside the lab and the world outside. Likewise, our active news and social media presence invites the broader community into MIT.nano. For example, to celebrate Nano Day (October 9), we released our Explorers of the Nano Age coloring book, in print and downloadable form. This coloring book profiles young faculty and their research at MIT, and has inspired both young and older audiences worldwide to engage and learn more.



Released for Nano Day 2022, MIT.nano's Explorers of the Nano Age coloring book celebrates early-career faculty who are using the tools of nanoscience and engineering to invent the world of tomorrow. Shown here is a sample of the coloring book.

Over 180 facility tours in FY2023 brought hundreds of visitors in person to MIT.nano from industry and startups; universities and academic organizations; US government and military; international government and organizations; and MIT DLCs and Offices. MIT.nano also welcomed admitted graduate students during EECS and DMSE visit weekends and hosted visits for prospective faculty.

Seeing the advanced toolsets through the windows is an exciting experience for many visitors; even more inspiring is an opportunity to step into the lab for a hands-on adventure. In the first half of 2023 alone, nearly 400 lab visitors gained in-person, hands-on experience in chip fabrication and/or packaging in MIT.nano laboratories. An

additional 67 high school students participated virtually through Lincoln Lab/MITRE-sponsored summer programs. Participating through events like our IAP fab classes; special lab sessions in academic classes; workforce development programs like the AIM Photonics workshops with local community colleges; and courses like the MIT Sloan Executive Education Advanced Management Program and the Monterrey Tec Nanolabs, people from inside and outside the MIT community came away with unforgettable experiences and greater appreciation for what nanoscience and nanotechnology can do. Since 2021, nearly 1,200 non-researchers have participated in a hands-on experience in the cleanroom fabrication and packaging facilities at MIT.nano.

Figure 3 - Visiting students proudly display the product of their very first hands-on experience in a cleanroom – a silicon wafer patterned with a group photo image of themselves.

Collaborations and Interactions across the Campus and Beyond

We use the convening power of MIT.nano to initiate discussions and host educational activities that can broadly define the next horizons of science and technology, informing the public and spurring activity in our immediate community and in the research world at large. Here are few examples of our activities:

- The bipartisan passage of the CHIPS and Science Act, US national legislation that provides $52 billion in federal investments for domestic semiconductor research, design, and manufacturing, in 2022 underscored the high priority placed on reasserting US leadership in microelectronics. Addressing a roundtable of university leaders convened during her visit to MIT.nano in August 2022, MA Senator Elizabeth Warren noted that federal funding would go into strengthening domestic manufacturing but also to the National Science Foundation for fundamental research targeted at solving practical problems.

- Faculty who are heavy users of MIT.nano as well as MIT.nano staff are also active participants in the Massachusetts Technology Collaborative (MassTech)-led Northeast Microelectronics Coalition (NEMC). Led by an advisory group that includes MIT and MIT Lincoln Laboratory, the 85+ organization coalition submitted a proposal in February 2023 to the Department of Defense's Microelectronics Commons program, funded by the 2022 CHIPS and Science Act. MIT.nano faculty and staff took a leading role in creating many elements of the proposal, which aims to create a regional hub that facilitates workforce training opportunities, supports hard tech startups, and establishes a network of shared technical facilities supporting broad innovation developments over all technology readiness level (TRL) stages.
- Through MIT.nano's collaboration with the Lab for Education and Application Prototypes (LEAP), housed on the fifth floor of MIT.nano and part of the AIM Photonics Academy, MIT.nano is involved in the MassTech's Massachusetts Manufacturing Innovation Initiative (M2I2), supporting workforce development in the Commonwealth of Massachusetts.
- MIT.nano is part of the vibrant MIT ecosystem that attracts global leaders in academia, industry, and government. MIT.nano welcomed President Yoon Suk Yeol of South Korea during his April 2023 visit to MIT; Intel CEO Pat Gelsinger during his March 2023 visit to MIT; US Under Secretary of Defense for Research and Engineering Heidi Shyu during her visit to MIT; Oscar-winning lyricist Chandrabose; and over 30 foreign ambassadors for a facility tour as part of the 28th Experience America trip led by the US Department of State and the Office of the Chief of Protocol, in March 2023.
- MIT.nano continues to work with the MIT Industrial Liaison Program (ILP) in developing strategic relationships with industry and global organizations.

Financial Sustainability and Programs

Financial Support

MIT.nano operations is financially supported by user fees, together with MIT.nano Consortium membership dues, MIT recurring and non-recurring support, donations, and funding dedicated for support of MIT.nano programs. During the last year, MIT.nano received support from the NCSOFT Gaming Program and the Tecnológico de Monterrey – MIT Nanotechnology Program.

Consortium

As of June 30, 2023, the MIT.nano Consortium consists of nine Member Companies. The financial support of the MIT.nano Consortium funds our operations, purchases of equipment, and seeds relevant research directions. As important, our industrial colleagues also introduce us to practical problems blocking the path to developing a better world, and when we overcome the challenges, they help to deliver our insights and innovations to the market. For our corporate collaborators, joining the potent problem-solving culture of innovation at MIT energizes their efforts and offers early awareness of the technological advances that will help shape the world of tomorrow.

Current MIT.nano Consortium members include Analog Devices (ADI), Draper, Edwards, Fujikura, IBM Research, Lam Research, NEC, Raith, and UpNano.

Programs

Programs hosted at MIT.nano leverage not only our technical facilities and research spaces but also draw on our unique ability to convene a diverse community of interests, spark interdisciplinary interactions and collaborations, and help to bolster MIT's ability to advance knowledge and innovation in service to a better world.

Tecnológico de Monterrey – MIT Nanotechnology Program – A multiyear partnership, now in its 8th year, between MIT and Tecnológico de Monterrey (Tec), a private, nonprofit university in Mexico, the program supported activities in academic education, research, and industry engagement. For example:

- NanoLab Workshops, a combination of virtual lectures (attended by 375 Monterrey Tec students) and a week-long in-person hands-on microfabrication course for Tec students hosted in MIT.nano labs (attended by 21 students).
- MIT-Tec Research Stays, a collaborative program that embeds Tec postdoctoral researchers into MIT faculty research groups for several months. In FY23 we hosted 5 Monterry Tec visitor stays. Since the program's inception, 84 students/postdocs who came to MIT as research scholars have become faculty at MTec!
- Development by students of a low-cost and reconfigurable Fiber Extrusion Device (FrED), an accessible and affordable smart desktop fiber extrusion system to be deployed at MIT and Tec for hands-on smart manufacturing education.

START.nano – The premise of START.nano is that early, discounted access to MIT.nano's state-of-the-art laboratories can minimize the cost of launching a nascent idea, helping increase the survival rate of promising companies and potentially shortening the time it takes for their innovations to reach the market. MIT.nano's accelerator program for hard-tech startups also exposes our academic users to the presence of startups in MIT.nano facilities and enhances MIT campus-wide partnerships to support entrepreneurship.

After a pilot program in AY2022, AY2023 was the first official year of START.nano. Twelve new companies with nanoscale technologies at the core of their business were accepted to the program, joining three from the 2021 inaugural cohort who stayed on for a second year. New this year, START.nano companies were also eligible to participate in the MIT Startup Exchange.

START.nano's third call for applications in March/April 2023 announced the addition of discounted access to the Immersion Lab as well as the fabrication and characterization facilities for START.nano company users. The call drew 33 applications from startup companies focused in a wide range of areas, including quantum computing, human-machine interfaces, novel manufacturing and energy solutions, augmented/virtual reality-enhanced applications, and healthcare. New companies selected and invited to join START.nano will be announced in AY2024.

Operational Model and Governance

Personnel

MIT.nano continues to increase staffing to maintain and operate the growing number of toolsets and serve internal and external users. As of June 30, 2023, MIT.nano staff includes 44.5 FTEs, or 48 individuals. Several staff members from MIT.nano, MRL, MTL, RLE and CEE were shared between facilities (with 10% to 50% of their time allocated to their work at MIT.nano).

Robert (Bob) Bicchieri, Research Specialist, was selected as an Outstanding Contributor in the 2023 MIT Excellence Awards.
In June 2023 VPR Zuber announced that instruments and staff of the shared experimental facilities (SEF) in Building 13, that were formerly managed by the Materials Research Lab (MRL), will on July 1, 2023 be merged into MIT.nano. Prof. Jim LeBeau will take on the newly created role of the co-director for characterization at MIT.nano, effective July 1, 2023, with responsibility for financial, facilities, and staff resources associated with Characterization.nano SEFs.

Profiled in MIT News, a core team of MIT.nano's technical staff who came from Building 39's MTL and NSL have more than 400 combined years of MIT and technical experience.

Diversity Initiatives

MIT.nano aims to provide a welcoming, safe, and enriching environment for all, creating a workplace that advances equity, opportunity, and belonging as we work side by side in advancing nanoscience and nanotechnology. Activities undertaken by the MIT.nano Diversity, Equity, Inclusion, and Belonging (DEI) committee included sharing resources between staff on a monthly basis, ensuring manager training on bias-free hiring, revising new employee onboarding procedures, conducting an anonymous staff survey on work-life satisfaction, providing users of MIT.nano with means of directly contacting the DEI committee, and expanding user/staff engagement events and social gatherings.

Leadership Council and Faculty Advocates Working Groups

The MIT.nano Leadership Council provides strategic advice to the MIT.nano faculty director on issues related to the operation, planning, and goals for the facility. The Council meets nine times per year: once a month, except for January, June, and August break.

As described in previous reports, the Fab.nano, Characterization.nano, and START.nano Faculty Advocates Working Groups are led jointly by MIT faculty and MIT.nano technical leads and provide input and advice for MIT.nano.

Looking Forward

Beyond its advanced laboratories equipped with specialized tools and instruments, MIT.nano is a place that brings people together—to tackle humanity's greatest challenges, to make unforeseen connections, and to pursue world-changing ideas with creativity, intelligence, and passion. The community of people who keep MIT.nano running together those who are using MIT.nano's tools/instruments to advance their transformative ideas are our most potent resource.

MIT.nano open-access facility for nanoscience and nanoengineering exists to function not just as an active laboratory space, but as an essential means to implement MIT's mission in research, innovation, and education. We, the staff of MIT.nano, continue to be inspired by our broad and growing user community as together we strive to Build a Better World.

Vladimir Bulović
MIT.nano Founding Director
Fariborz Maseeh (1990) Professor of Emerging Technology
Professor of Electrical Engineering