Report to the President year ended June 30, 2024 MIT.nano

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

DELIVERING IMPACT

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.

As MIT.nano has moved from startup to steady state operation, its shared central facilities are enabling and amplifying MIT research, hands-on teaching, outreach, and innovation on campus and beyond.

CONTINUING USER BASE GROWTH

In FY2024, MIT.nano supported 1500+ lab users from over 370 principal investigators (PIs), which included both internal MIT (students, postdocs, staff, faculty) as well as external academic and industry users. These numbers reflect continuing growth of our overall user base.

Approximately 1160 internal users came from 235 PI groups from across the Institute, primarily from the Schools of Engineering and Science, but also from the School of Architecture and Planning; and the School of Humanities, Arts, and Social Sciences. In addition, the over 340 external users (~20% of our user base) came from over 100 industry, startup, and academic organizations outside of MIT.

The significant increase in the number of users who are utilizing both fab and characterization facilities suggests a positive shift towards combined services utilization. Additionally, the substantial rise in external users indicates increasing external collaboration and interest in the facilities/services provided.

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), Earth, Atmospheric & Planetary Sciences (EAPS), Electrical Engineering and Computer Science (EECS), Materials Science and Engineering (DMSE), Mechanical Engineering (MechE), Music Theater Arts (MTA), Nuclear Science and Engineering (NSE), Physics, Program in Art, Culture and Technology (ACT), Program in Media Arts and Sciences (MAS), Urban Studies & Planning (DUSP)
- *Laboratories, Centers, Institutes, and Offices*: Computer Science and Artificial Intelligence Laboratory (CSAIL), 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), MIT Energy Initiative, Nuclear Reactor Laboratory, 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. MIT.nano shared tools and instruments are primarily organized around three major areas: Fab.nano (micro/nanofabrication), Characterization.nano (metrology and materials characterization), and Immersion Lab (physical/digital and data visualization).

Below we highlight three specific areas targeted in FY2024 to improve user experience:

Streamlining the user sign-on process:

We continued the work described in last year's report towards streamlining the new user onboarding process in order to expedite the users access to the MIT.nano Shared Experimental Facilities (SEFs), while reducing the busy work of our administrative and technical staff. This year we placed additional emphasis on instituting standard, cadenced schedules for user orientation sessions and group trainings, allowing users to more quickly complete required trainings in sequence and plan for instrument-specific training.

With the merger of Characterization.nano and MRL SEFs, in September 2023 we consolidated what had been two separate, but similarly-named, user management systems, thereby eliminating a source of confusion for users. All user credentials, billing information, and instrument operations were transferred without facility downtime, and starting from the October 2023 billing cycle, all users began receiving a single bill for combined usage from all MIT.nano SEFs.

Modernizing the laboratory management system:

MIT.nano's laboratory management system (LMS) for equipment scheduling and tool control was inherited from the former MTL cleanrooms and has been in use for over two decades. Since the opening of MIT.nano (six years ago) a significant effort has been invested to identify and begin transitioning to a replacement LMS with a more modern interface, greater flexibility, and mobile functionality. Following extensive consultations with other Universities we identified NEMO, an open-source laboratory logistics software originally developed at the National Institute of Standards and Technology. Integration of NEMO with MIT.nano's existing user account, permissions, and billing management system required significant backend upgrades, following which we rolled out the new NEMO interface to Characterization.nano and Immersion Lab users in June 2024. Fab.nano will transition to NEMO in FY2025. Users have found the intuitive interface easy to use, particularly now with the ability to access and book equipment schedules from personal mobile devices.

Reinforcing a culture of safety:

Described in last year's report, MIT.nano's Safety Circuits program has continued to promote best practices in the lab, increase communication and visibility of staff members among MIT.nano users, and promote safety as a shared responsibility. In FY2024, we made several updates to further facilitate cleanroom lab safety, including:

- updating color-coding system to reduce the chances of incompatible materials being used together
- upgrading personal protective equipment for acids, bases, and developer, including provision of additional apparel sizes to ensure that we are more inclusive
- automating training reconciliation to ensure that cleanroom access is rapidly granted to users with 100% training completions

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.

Supporting hands-on education: Academic class support

MIT.nano staff continued to support multiple academic classes in AY2024, assisting with the development of new classes as well as providing class instruction time at no cost to the academic departments. For the third year, two classes that heavily utilize MIT.nano's toolsets 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 Professor Farnaz Niroui of Electrical Engineering and Computer Science
- *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 AY2024 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 Immersion Lab hosted additional classes, including CMS.342/942 (**MechE/CMS**); 9.S52/9.S915 (**BCS**), MAS.S64 (**MAS**), and 21M.862 (**MTA**).

The School of Architecture class 4.373/4 *("Creating Art, Thinking Science")*, now in its third year, was again taught by Lecturer Tobias Putrih of the Program for Art, Culture, and Technology in collaboration with MIT.nano director Vladimir Bulović. Supported by an interdisciplinary Class Development Grant from the MIT Center for Art, Science and Technology, the class offered art students unique access to advanced MIT.nano facilities and ongoing research. Artwork generated by the students in the class is exhibited in the hallway galleries of MIT.nano.

In addition to the tools and instruments installed inside, the building infrastructure itself offers learning opportunities: this year undergraduate students in *1.080 Environmental Chemistry* (**CEE**) visited to learn about Building 12 operations, with special emphasis on its abatement systems and engineering for the prevention and remediation of pollution.

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 FY2024 eight early career faculty were granted Young Faculty Awards:

- Joseph Casamento , Assistant Professor of Materials Science and Engineering
- Ericmoore Jossou, Assistant Professor of Nuclear Science and Engineering
- Long Ju , Assistant Professor of Physics
- Sam Peng , Assistant Professor of Chemistry
- Carlos Portela , Assistant Professor of Mechanical Engineering
- Vivishek Sudhir , Assistant Professor of Mechanical Engineering
- Ritu Raman, Assistant Professor of Mechanical Engineering
- Loza Tadesse, Assistant Professor of Mechanical Engineering

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 – As in previous years, MIT.nano maintains relationships with other core facilities to enable instrumentation/capabilities coordination across campus and our regional partners, including: Koch Institute; Institute for Soldier Nanotechnologies; Ragon Institute of MGH, MIT, and Harvard; and W. M. Keck Microscopy Facility at Whitehead Institute.

Immersion Lab – As in past years, we have carried on sharing physiological sensing equipment and other resources with the MIT Center for Clinical and Translational Research (CCTR), particularly to aid users performing human subjects research.

EXPANSION in 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 FY2024 MIT.nano completed the bulk of Phase 4 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 kicked off in April 2023 and was completed in July 2024.

Phase 4 activities involved 53 construction drawings, 39 coordination meetings, 16 vendors, and included:

- the addition/renovation of twelve office spaces to meet a pressing need for additional staff offices in Building 12
- structural repair of the bulk tank farm that holds and supplies liquid nitrogen to the fab and characterization facilities throughout Building 12
- installation of additional tools
- decommissioning and decontamination of Building 39 spaces

Decommissioned Building 39 former shared laboratory spaces

In Phase 4, the former MTL fab and Nanostructures Laboratory (NSL) shared facilities in Building 39 were fully decommissioned and vacated. In keeping with our commitment to environmental sustainability, in November 2023, MIT.nano worked with the MIT Office of Sustainability to host two "Freecycle" community events to redistribute surplus equipment and supplies from the

cleanout of former lab spaces in Building 39. The hundreds of people who came collected dozens of items for reuse/upcycling, successfully diverting them from recycling/trash.

New tool acquisition and installations

Presently there are more than 215 tools and instruments available to users in MIT.nano. We highlight just a few of the recent updates below:

- direct write laser lithography system (Raith Picomaster 200) capable of high-dynamic range grayscale lithography and automated exposure operations
- fully integrated optical profiling microscope (KLA Zeta 20) that provides three-dimensional metrology and imaging capabilities
- three new atmospheric diffusion/anneal/sinter furnaces (Expertech), plus two low-pressure chemical vapor deposition furnaces anticipated to start up in mid-2024
- new deposition systems, including a plasma-enhanced chemical vapor deposition system for high quality silicon dioxide films, atomic layer deposition system for nitrides, and additional physical vapor deposition evaporator
- two new reactive ion etch systems (Plasmatherm Corial)
- addition of nanomanipulator (Oxford OmniProbe 400), with nanometer resolution piezo actuators and sub-degree position accuracy, onto existing FEI Helios 600 focused ion beam/scanning electron microscope, both augmenting its capabilities and prolonging the useful life of the aging, 15 year old electron microscope
- software and hardware upgrades to x-ray photoelectron spectroscopy (XPS) system (Versaprobe), adding new features for automated data acquisition and prolonging the useful life of the aging, 13 year old XPS

The Characterization.nano X-ray facility located in 13-4027 completed renovations in January 2024; the facility serves over 300 external and internal users annually. With support from VPR, in FY2025 we expect to upgrade and replace some of the aging x-ray instruments in the newly renovated space.

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 to 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.

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 to engage with 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 2024 (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. In its 20th year, the student-led conference gathered over 250 attendees and featured 130+ student abstracts. As in previous years, MARC 2024 was held in conjunction with the Quantum Science and Engineering Annual Research Conference (QuARC).
- **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. The final AY2024 talk brought back a previous Nano Explorations speaker, Richard Swartwout, who shared his journey from his graduate research work on perovskite thin films for solar cells to spinning up Active Surfaces, Inc., a startup company dedicated to making flexible solar technology a reality.
- **Tool Talks** – Technical presentations sponsored by individual tool/instrument suppliers, Tool Talks offered users an opportunity both to be introduced to 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 9 Tool Talks brought participants together for in-depth technology discussions and hands-on demonstrations.
- **Characterization.nano User Forums** – Formally started in April 2024, the bi-monthly forums offered topically focused user talks and a channel for general user feedback.
- **Nano PI Lunches** – First held in December 2023, these informal monthly lunches helped deepen the connections of our broad PI community, with central discussion topics that touched upon characterization, fab, immersion, education, entrepreneurship, corporate engagement, arts, and more.

Engaging the broader MIT community

"Nano" is not a specific technology, nor does it belong to a particular discipline or industry – hence it brings wide opportunity and appeal. In addition to engaging its users, in AY2024 MIT.nano sought to engage the broader MIT community through a range of activities, such as:

- **MIT.nano Seminar Series** – Organized and led by Professor Farnaz Niroui, the monthly seminars brought guest lecturers from across the spectrum of nanoscience and nanoengineering, with both academic and industry lecturers, 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 2023 lecture was delivered by Angela Belcher, the James Mason Crafts Professor of Biological Engineering at MIT. Speaking to a combined in-person and virtual audience of over 300, Belcher discussed using viruses to control materials at the nanoscale and develop solutions in energy, environment, and medicine.
- **IAP classes** – Nearly 390 students, alumni, and faculty/staff participated in the four IAP classes offered by MIT.nano in January 2024: an extremely popular course featuring hands-on fabrication in the cleanroom, an introduction to electron beam lithography, beginning VR/AR software development, and, new this year, an introduction to crystallographic structure determination with x-ray and electron microscopies.
- **ARTS.nano** – In December 2023, MIT.nano and the MIT Program of Art, Culture, and Technology celebrated three years of collaborations with a special event and the opening of student art exhibition ".zerozerozerozerozerozerozeroone." In May 2024, MIT.nano's One.MIT art project unveiled its third edition, inscribing nearly 340,000 names of MIT faculty, staff, students, and alumni from 1861 to the present onto an 8" silicon wafer. Designed by Professor W. Craig Carter of Materials Science and Engineering, the new wafer installed in the first floor gallery was fabricated by a team of current students, faculty, staff, and alumni right in the fabrication facilities located on the other side of the gallery wall.
- **Deep Tech Career Fair** – The annual MIT.nano-led multi-consortium career fair was held on September 21, 2023, attracting over 200 students. This year, industry members of the MIT AI Hardware Program joined MIT.nano Consortium members, Microsystems Technology Laboratory Industrial Group, and Quantum Science & Engineering Consortium (QSEC) in engaging students.
- **Coffee, Cookies & Conversation + Ice Cream Socials** – MIT.nano's monthly social gatherings, over coffee and treats, inviting all MIT.nano users, staff, and faculty for an informal gathering.

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.

- In celebration of five years of serving our community, MIT.nano released five videos for Nano Day 2023. The videos showcase our three main facilities—Characterization, Fab, and Immersion Lab—and look back at where we started in 2018 and celebrate the MIT.nano community of 2023.
- Similar to last year, over 180 facility tours in FY2024 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. This year we noted that many tour requests came from external visitors inspired by our operations and interested in building their own similar facilities. MIT.nano also welcomed admitted graduate students during EECS and DMSE visit weekends and hosted visits for prospective faculty.
- Many additional visitors engaged further by stepping into MIT.nano labs for actual hands-on experience in chip fabrication and/or packaging, 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.
- Partnerships with MIT outreach programs gave middle school and high school students an opportunity for hands-on scientific exploration of the micro to nano world. For example, in November 2023 MIT.nano hosted the pilot event for the graduate student-led Electron Microscopy Elevating Representation and Growth in Education (EMERGE) program, which was also supported by DMSE and the School of Engineering's MIT Introduction to Technology, Engineering, and Science (MITES) program.

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 24th University/Government/Industry Micro/Nanotechnology (**UGIM**) Symposium was held at MIT on June 23–26, 2024. Hosted at different sites nationwide for each iteration, the biennial UGIM Symposium brings together educators and researchers involved in micro/nanotechnology lab management around the world and provides a forum for exchanging information and presenting new lab operations and educational concepts. Representatives of micro/nano fabrication and characterization facilities, ranging from new labs to nationally and internationally recognized facilities, attend UGIM

to discuss topics that include industry/university interactions, new equipment trends, best practices, collaborative research, and training efforts.

Organized by Dr. Jorg Scholvin, MIT.nano Associate Director of Fab.nano, and Dr. Anna Osherov, MIT.nano Associate Director of Characterization.nano, the 2024 UGIM symposium was supported by 45 industry sponsors and brought over 300 attendees from 82 universities/labs and 67 companies, representing 31 states and 14 countries. Post-event comments from attendees highlighted that the conference and atmosphere was accessible to all, newcomers as well as veterans, with a "great mix of learning, discussion, and socializing."

- The inaugural **Nano Summit** was held on October 24, 2023, in collaboration with the MIT Industrial Liaison Program (ILP), a continuing partner in developing strategic relationships with industry and global organizations. Launched in time to celebrate our fifth-year anniversary, the conference highlighted recent developments in quantum science and engineering, materials, advanced electronics, energy, biology, and immersive data technology. Invited speakers from across MIT explored how these innovations address grand challenges and examined pathways to bring these solutions to the marketplace.

- Faculty who are heavy users of MIT.nano as well as MIT.nano staff are active participants in the Massachusetts Technology Collaborative (MassTech)-led Northeast Microelectronics Coalition (NEMC). In September 2023 the U.S. Department of Defense (DoD) selected the **NEMC Hub** as one of eight Microelectronics Commons regional innovation hubs. The awarded funding, from the 2022 CHIPS and Science Act, will enable NEMC to accelerate the transition of critical microelectronics technologies from lab-to-fab, spur new jobs, expand workforce training opportunities, and invest in the region's advanced manufacturing and technology sectors. Leaders from the DoD and the director of Microelectronics Commons at NSTXL, the National Security Technology Accelerator, made a site visit to the NEMC Hub on January 30, 2024. The visit included facility tours and a startup showcase at MIT.nano.

- In January 2024, MIT and Applied Materials, Inc. announced an agreement that, together with a grant to MIT from the NEMC Hub, committed more than $40 million of estimated private and public investment to add advanced nanofabrication equipment and capabilities to MIT.nano. The collaboration will create a unique open-access site in the United State that supports research and development at industry-compatible scale using the same equipment found in high-volume production fabs to accelerate advances in silicon and compound semiconductors, power electronics, optical computing, analog devices, and other critical technologies. The new equipment, provided by Applied Materials, will significantly expand MIT.nano's nanofabrication capabilities for wafers up to 200mm in diameter, a size widely used in industry. Delivery, installation, and startup are expected to be completed in FY2025.

- 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. As just one example, in February 2024, the Global Semiconductor Alliance Women's Leadership Initiative brought in leaders from top semiconductor companies for a half-day event, co-sponsored by MIT.nano, aimed at inspiring and recruiting students into high-impact careers in the semiconductor industry.

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 Tecnológico de Monterrey – MIT Nanotechnology Program as well as philanthropic gifts from FEMSA and the Tony James Foundation. Additional funding was granted from the Northeast Microelectronics Coalition Hub to enable the installation of advanced nanofabrication equipment provided by Applied Materials.

Consortium

As of June 30, 2024, the MIT.nano Consortium consists of thirteen Member Companies. The financial support of the MIT.nano Consortium funds our operations, purchases of equipment, young faculty support, and seeds relevant research directions. As important, our industrial colleagues also introduce us to practical challenges that are blocking their path to the developing technologies for a better world. 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), Applied Materials, Draper, Edwards, Fujikura, IBM Research, Lam Research, Lockheed Martin, NEC, Shell, UpNano,** and a **U.S. government agency**.

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 boost MIT's ability to advance knowledge and innovation in service to a better world. Examples include:

- **Tecnológico de Monterrey – MIT Nanotechnology Program** – A multiyear endowed partnership first established in 2014 between MIT and Tecnológico de Monterrey (Tec), a private, nonprofit university in Mexico, the program's three main pillars supported robust collaborations, innovation education initiatives, and dedicated research efforts:
    - *nanoLab* – A combination of virtual lectures and a week-long in-person hands-on microfabrication course for Tec students hosted in MIT.nano labs, the nanoLab course has reached 1,163 Tec students since 2014.
    - *MIT-Tec Research Stays* – A collaborative program that embeds Tec postdoctoral researchers into MIT faculty research groups for several months, in FY2024 we hosted 9 Tec visitors, several overlapping from FY2023 and several into FY2025. Since its inception in 2015, the program has hosted 40+ Tec visitors and involved 12 different DLCs and 23 MIT PIs.
    - *FrED Factory* – An integral component of MIT-Tec Program educational initiatives, the student-developed low-cost and reconfigurable Fiber Extrusion Device (FrED) serves as a lab-in-a-box solution to make hands-on engineering education and research more accessible. Utilized in undergraduate and graduate classes at both MIT and Tec de Monterrey, the FrED curriculum has expanded to include the FrED Factory, high-mix, low-volume production facilities, located on MIT and Tec campuses. Since launching the FrED curriculum at Tec de Monterrey in 2022, we have hosted the following courses:
        - *(Re) Design of FrED***:** Projects of Mechatronics Engineering (36 student participants)
        - *FrED Factory (1st, 2nd, 3rd generations):* Automation of Manufacturing Systems (88 student participants)

- **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 in support of entrepreneurship.

  In FY2024, ten companies in START.nano's 2023 cohort – spanning the hard tech sphere from AI hardware and quantum computing to clean tech materials and biomedical technologies – benefited from discounted access to Fabrication, Characterization, and Immersion Lab facilities. In addition, the continued use of MIT.nano facilities by previous

START.nano cohorts demonstrates the importance of giving access to startups to propel their development of high-impact technologies that will shape the world to come. Recognizing the value to startup development of high-impact technologies, FEMSA Foundation made a philanthropic gift in FY2024 in support of the START.nano program.

OPERATIONAL MODEL and GOVERNANCE

Personnel

MIT.nano continues to increase staffing to maintain and operate the growing number of toolsets and serve the increasing number of internal and external users. As of June 30, 2024, MIT.nano staff includes 50 FTEs, corresponding to 60 individuals, with several staff members from MIT.nano, MTL, RLE, IMES, and CEE shared between facilities (with 10% to 50% of their time allocated to their work at MIT.nano).

On July 1, 2023, the instruments and staff of the shared experimental facilities (SEF) in Building 13, formerly managed by the Materials Research Lab (MRL), merged into MIT.nano. In a newly created role, Professor James LeBeau became co-director for characterization at MIT.nano, with responsibility for financial, facilities, and staff resources associated with Characterization.nano SEFs.

DEIB initiative

MIT.nano aims to provide a welcoming, safe, and enriching environment for all, creating a workplace that advances equity, opportunity, and belonging side-by-side as we work in advancing nanoscience and nanotechnology. The ten-member Diversity, Equity, Inclusion, and Belonging (DEIB) committee's activities included conducting an anonymous staff survey on work-life satisfaction; ensuring manager training on bias-free hiring; revising new employee onboarding procedures; sharing DEIB resources between staff; and expanding user/staff engagement events and social gatherings.

Leadership Council and Faculty Engagement

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. The current members are: Dr. Brian Anthony (MechE), Dr. Robert Atkins (MIT LL), Kathy Boisvert (MIT.nano), Professor Vladimir Bulovic (MIT.nano), Professor Pablo Jarillo-Herrero (Physics), Associate Professor James LeBeau (DMSE), Professor William Oliver (Physics), Professor Tomas Palacios (EECS, MTL), Professor Katharina Ribbeck (Biological Engineering), Professor Frances Ross (DMSE), Professor Thomas Schwartz (Biology), Professor Carl Thompson (DMSE, MRL), and Professor Kripa Varanasi (MechE).

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 are using MIT.nano's tools/instruments to advance their transformative ideas—together with the dedicated staff who keep MIT.nano running—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