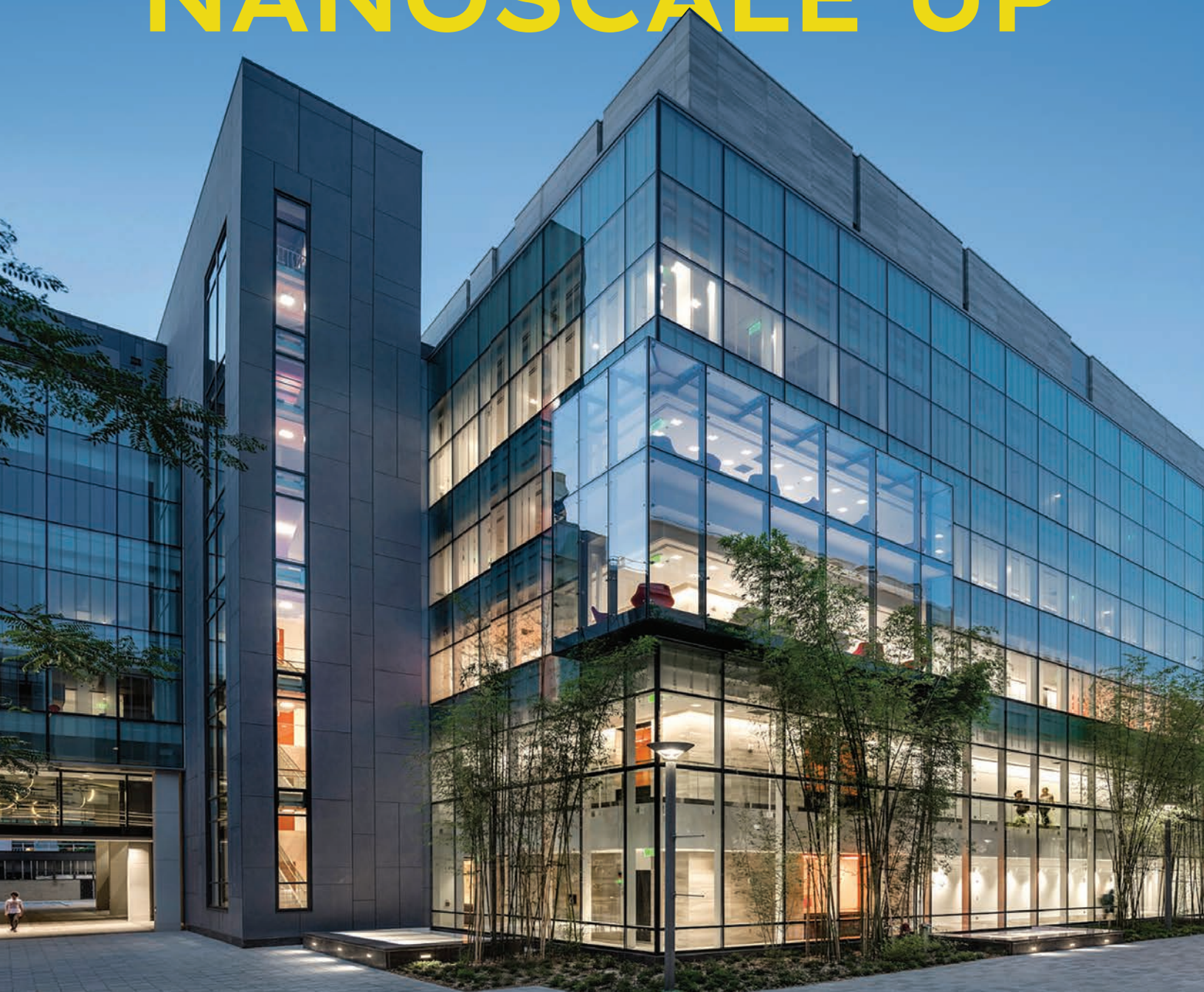
MIT.nano | **LISA T. SU BUILDING**
Building 12 at MIT

POWERING INNOVATION FROM THE NANOSCALE UP



STEP INTO THE NANO AGE

Over the past half century, humanity has developed the breathtaking power to manipulate matter at the level of individual atoms and molecules. Our capacity to understand nature at the smallest of scales, and to design materials just nanometers in dimension, is revolutionizing how we shape our world and launching a thrilling new age of discovery and innovation.

The 21st century is facing problems whose urgency and complexity stretch around the globe. Incremental change will not provide solutions soon enough or at scale. Nanoscience and nanotechnology are our best tools to produce the transformative change humanity needs to confront challenges in health and energy, or clean water and climate. To establish new paradigms for computing and communications, or manufacturing and materials. To transform existing industries—and invent new ones. And with these innovations as our foundation, to build a better world.

MIT.NANO IS THE INSTITUTE'S VESSEL TO EXPLORE THIS NEW ERA AND DELIVER A BETTER FUTURE.

Associate Director for Fab.nano Jorg Scholvin explains the PicoTrack, a fully automated coat-and-develop track system for spin coating, spray developing, and puddle developing of 6-inch and 8-inch wafers, to a group of MIT undergraduates.

MIT.NANO IS…

The Institute's central resource for nanoscale discovery and innovation, set in the heart of the campus in the Lisa T. Su Building.

One of the largest, most advanced, and most accessible university research facilities of its kind in the United States.

214,000 square feet in total, with more than 100,000 square feet of high-performance laboratory space and 45,000 square feet of ISO 5, 6, 7 (class 100, 1,000, 10,000) cleanroom.

Open access, with shared toolsets and spaces available to qualified researchers from across MIT, as well as external users from industry, academia, and government.

A resource for the region and the nation as the core facility for the Northeast Microelectronics Coalition Hub (NEMC).

A nexus for cross-disciplinary problem solving, serving more than 250 MIT PI laboratories drawn from nearly 50 MIT departments, labs, and centers.

A hub offering seminars, seed grants, exhibitions, conferences, startup support, and other programs that connect inside and outside of MIT.

MIT.NANO IS DESIGNED—AND POSITIONED—FOR IMPACT

The advanced facilities of the Lisa T. Su Building extend over five floors, built from the ground up to support discovery and invention. And the building itself is situated at the center of a remarkable hub for innovation—a thriving area of life science, high tech, and clean energy companies; accelerators, incubators, and venture firms; startups and global leaders, all anchored on and around the MIT campus.

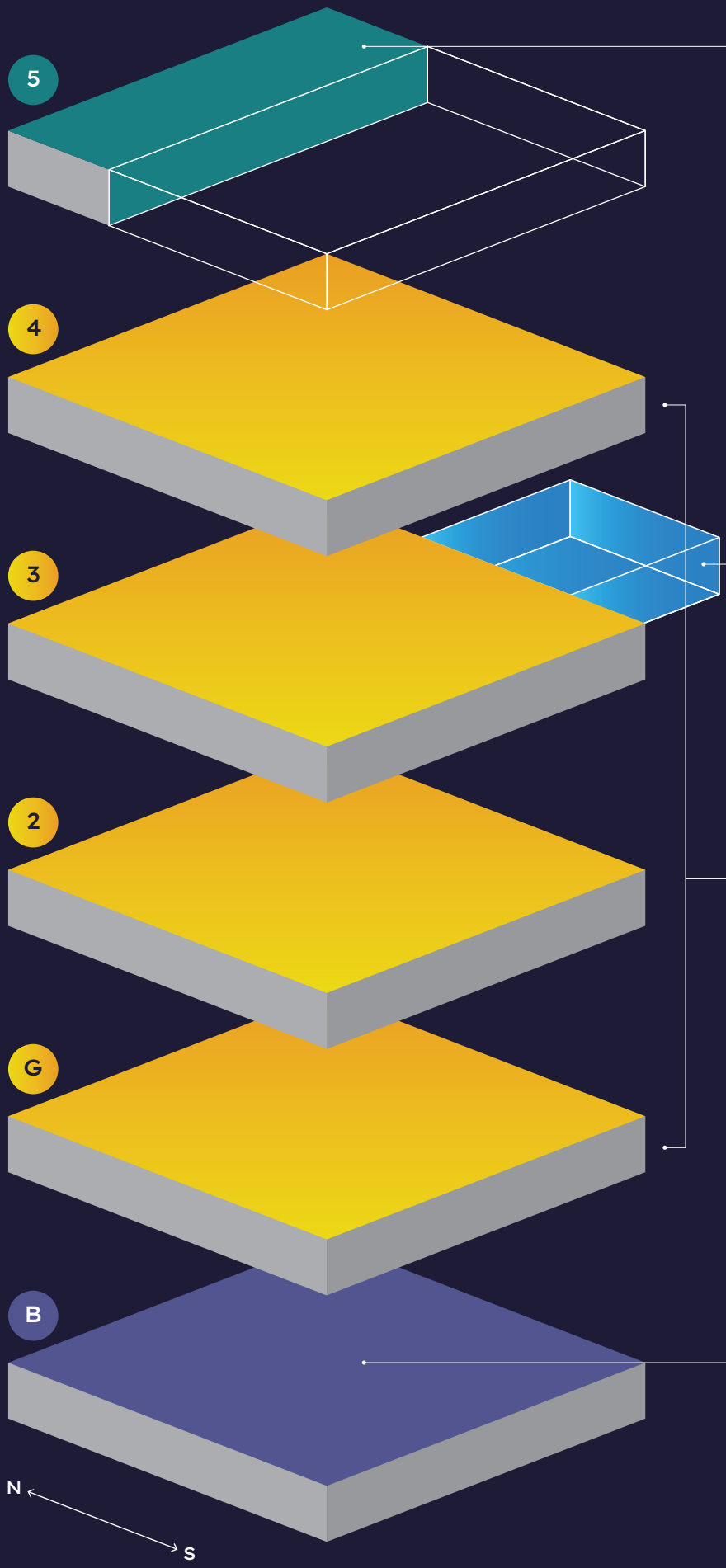
INNOVATION RADIATES FROM MIT OUT

Hundreds of companies and startups are based within minutes of MIT and MIT.nano, forming "the most innovative square mile on the planet."

- MIT Buildings
- Bio/Pharma
- Venture Capital
- Energy
- Tech/Data

We are LEED Platinum

Our commitment to sustainability has earned the U.S. Green Building Council's highest designation for a building's environmental attributes.



PROTOTYPING

A unique set of interconnecting labs—the first of its kind at MIT—with capabilities for fabrication, additive manufacturing and 3D printing, prototyping, and packaging.

IMMERSION LAB

An environment to connect the physical to the digital—visualizing data, prototyping advanced tools for augmented and virtual reality (AR/VR), and developing software and hardware concepts for immersive experiences.

FABRICATION

Two levels over four floors comprising more than 45,000 square feet of ISO 5, 6, 7 (class 100, 1,000, 10,000) cleanroom with capabilities spanning lithography, etching, deposition, diffusion, and wet processing.

CHARACTERIZATION

11,000 square feet for metrology and characterization including 12 sophisticated suites for nanoscale observation with low vibration and minimal electro-magnetic interference.

MIT.nano's fabrication facility supports a wide variety of experimental processes with toolsets that accommodate sample sizes ranging from small chips and pieces up to 200mm wafers. Here, a researcher loads a 200mm wafer into one of two Plasmatherm Reactive Ion Etchers (RIE) installed in the facility.

FABRICATION

The heart of MIT.nano is approximately 50,000 square feet of ISO 5, 6, 7 (class 100, 1,000, 10,000) cleanroom for the design, fabrication, and analysis of micro and nanoscale structures and devices.

This substantial area currently supports more than 1,500 qualified researchers annually—with room to grow. The size, sophistication, and sensitivity of the labs enable us to incorporate a broad and expanding range of tools for additive, subtractive, and patterning processes; thermal processes; metrology; and packaging and assembly.

Focus facilities—such as nanomaterials, thin-film processing, and microfluidic assembly and testing—support critical research thrusts. The Tecnológico de Monterrey Prototyping Space is a specialized extension of the cleanroom with multiple bays for tools that enable researchers to translate their insights and innovations into devices, products, and technologies that can be taken out into the world.

Since the Lisa T. Su Building opened its doors in 2018, MIT.nano has installed more than 200 tools and instruments. Even with this substantial toolset, the facility is at just three-quarters of capacity. MIT.nano is currently engaging the MIT community, our industry collaborators, and other partners to envision how to augment our capabilities to support novel applications and new research directions.

Our tools support a wide spectrum of nanofabrication processes including:

LITHOGRAPHY

- Two electron-beam lithography tools
- Four direct-write maskless aligners
- Automated wafer-coater and developer
- Two two-photon 3D exposure systems

DEPOSITION

- Multiple Atomic Layer Deposition (ALD) tools, including plasma-ALD
- Thermal and electron-beam evaporators
- Multiple sputter tools for thin-film deposition
- Four Plasma Enhanced Chemical Vapor Deposition (PECVD) tools

DRY ETCHING

- Multiple Reactive Ion Etchers (RIE)
- Multiple Inductively Coupled Plasma etchers (ICP) including Deep Reactive Ion Etching (DRIE)
- Six plasma ashers, including automated wafer and barrel ashers

DIFFUSION

- Four Rapid Thermal Processing (RTP) tools
- Oxidation/anneal furnace
- Three LPCVD furnaces for doped/undoped Si and nitride

WET PROCESSING

- Wet benches for corrosive cleaning and etch
- Hoods for general corrosive processing
- Hoods for solvent and lithography processing
- Soft lithography suite for microfluidic devices

METROLOGY

- Thin-film measurement (spectroscopic ellipsometry and reflectrometry)
- Full-wafer Atomic Force Microscope (AFM)
- Full-wafer Scanning Electron Microscope (SEM)

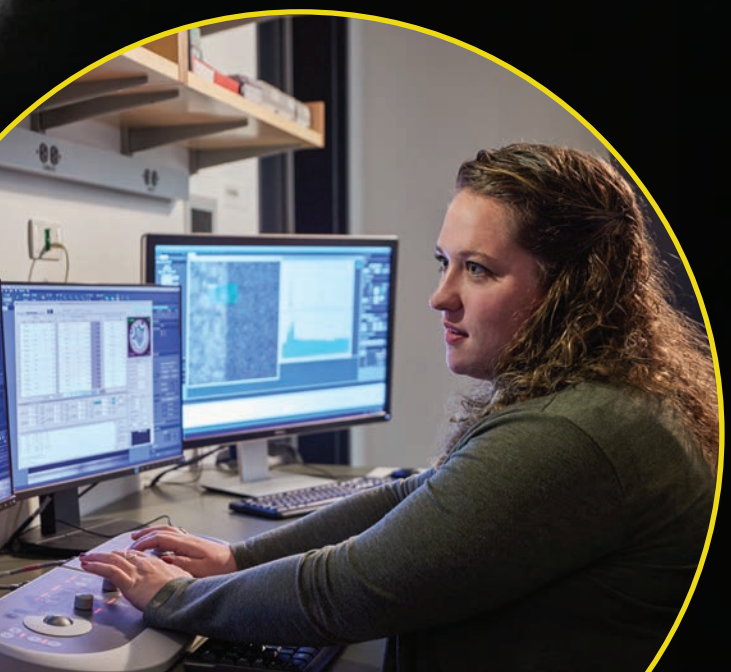
Individual moving atoms imaged using the Thermo Fisher Scientific Titan Themis Z G3 aberration-corrected scanning transmission electron microscope in MIT.nano's characterization facility.

CHARACTERIZATION

To see and measure at the nanoscale, you need ultra-stable and ultra-quiet conditions, with extremely low vibration and electromagnetic interference (EMI). MIT.nano's 11,000-square-foot characterization space was built with these critical factors in mind. Our 12 imaging suites are rated Vibration Criteria E & G. Each level is challenging to achieve; a VC-G level of quiet is unparalleled in any other U.S. academic institution. The result has been exceptional and even record-setting performance across a variety of our instruments.

MIT.nano's characterization suites house an array of highly sensitive microscopes and other instrumentation. Our state-of-the-art tools support dimensional science of surfaces and interfaces, advanced imaging spectroscopy (ambient, Cryo, and in-situ), and nanoscale analysis. Like the rest of MIT.nano, the user base is drawn from a broad set of interests. The facility now advances the investigations of hundreds of researchers from more than a dozen academic departments plus users from industry, other institutions, and startups.

When researchers come to MIT.nano, they are supported by experienced technical staff who help users gain the closest, clearest possible view of their work.



Our facility supports a broad range of characterization, metrology, and analysis instrumentation, including:

SCANNING PROBE MICROSCOPY

- Atomic force microscopy
- Kelvin force probe microscopy
- Magnetic force microscopy
- Piezo force microscopy

ELECTRON MICROSCOPY

- Focused ion beam scanning electron microscopy
- Scanning electron microscopy
- Scanning transmission electron microscopy

X-RAY DIFFRACTION AND IMAGING

- Grazing-incidence
- High-resolution X-ray diffraction
- Small- and wide-angle X-ray scattering
- Thin film, single crystal and powder X-ray diffraction
- X-ray reflectivity
- X-ray tomography

ANALYSIS AND SPECTROSCOPY

- Energy dispersive spectroscopy
- Hyperspectral imaging
- Surface sensitive elemental and chemical analysis
- Transmission, reflection or attenuated total reflection measurements
- Vibrational spectroscopy

CRYOGENIC ELECTRON MICROSCOPY

- Cryogenic focused ion beam scanning electron microscopy
- High-throughput cryogenic transmission electron microscopy
- High-resolution structure visualization and electron tomography
- Single-particle cryo-EM imaging

We have ample sample preparation as well as in-situ characterization capabilities including, nanoscale mechanical testing, environmental measurement and imaging setups, and temperature controlled characterization.

Motion capture and wireless physiological sensors are helping researchers explore how biomechanical feedback and interactive visualization tools could change the future of sports.

THE IMMERSION LAB

In this two-story, 800-square-foot cube, researchers are connecting the physical and the digital: visualizing and manipulating large data sets, prototyping advanced tools for AR/VR/XR, and developing software and hardware paradigms.

The MIT.nano Immersion Lab specializes in obtaining high-precision, real-time data. Custom software and analyses augment an open-source code base for educators and researchers. Our tools can be used across a wide range of application areas, from scientific data visualizations and industrial simulations to innovative gaming paradigms and creative artistic expression.

The lab not only contains an array of individual equipment and platforms, but is also, itself, an instrument. Embedded systems including sensors, cameras, and other tracking technologies enable room-scale monitoring of people and objects. A major focus of the lab is to support data exploration, allowing users to analyze their research at the human scale with large, multidimensional views, enabling visual, haptic, and aural representations.

The Immersion Lab's purpose is to move beyond hype and deliver practical applications of these promising technologies. The result is an intriguing crossroads for disciplines and industries that do not typically share the same space—gaming, prototyping sensors and hardware, biofeedback for athletics, new modes of teaching and learning, technology training simulations, physiological measurement, data visualization for scientific research, dance and musical performance, and medical studies and health analysis.

Augmented and virtual reality make it possible for instructors to bring students to environments that are hard to access, either geographically or at scale.

MAJOR THEMES

The Immersion Lab enables / empowers students, artists, and investigators in the following thematic areas:

- Biomechanics and physiology
- Data visualizations and simulations
- Human in the loop
- Multi-faceted research
- Performance and the arts

CAPABILITIES

If a topic can be imagined, the Immersion Lab can help envision it in virtual reality, mixed reality, and beyond. Our capabilities include:

Motion Capture

- Embedded 30-camera OptiTrack system with infrared and visible color imaging capabilities
- Removable accelerometer-embedded wooden floor

Physiological Monitoring

(In partnership with the MIT Center for Clinical and Translational Research)

- Delsys Trigno wireless sensor system
- Telemed ultrasound imaging
- VO2 Master breath analyzer, core temperature monitors, heart rate sensors, EMG, IMUs

Augmented / Virtual Reality

- Vario XR-3 mixed reality headsets
- HoloLens2 AR headsets
- HP Reverb G2 Omnicept VR headsets with built-in physiological monitoring
- Additional headsets for education/gaming

Digital Twins

- Lenscloud 3D scanner for human-scale objects
- Matterport Pro2 photogrammetric camera
- 360-degree cameras

High Performance Workstations

- Specialized for data science, digital content creation, and/or real-time data acquisition

Spatial Sound

- Dolby Atmos 7.1

CONVENING AND CONNECTING

MIT.nano draws researchers, inventors, and educators from departments and disciplines across the campus. In conjunction with our technical facilities and research spaces, MIT.nano offers programs to convene this diverse community of interests, to spark interdisciplinary interactions and collaborations, and to bolster MIT's ability to advance knowledge and innovation in service to a better world.

An MIT undergraduate presents her research, carried out in MIT.nano's facilities, at the Microsystems Annual Research Conference.

SYMPOSIA & CONFERENCES

THE NANO SUMMIT

The Nano Summit: MIT.nano's annual flagship conference, showcasing groundbreaking advancements in nanoscience and nanotechnology. The Summit convenes researchers, industry professionals, entrepreneurs, and students interested in the latest developments in cutting-edge research, emerging technologies, and real-world applications.

Microsystems and Quantum Annual Research Conferences (MARC & QuARC): Co-sponsored by the MIT Microsystems Technology Laboratories (MTL) and MIT Center for Quantum Engineering (QSEC) respectively, these annual events bring together MIT students, faculty, and members of industry to explore 100+ current research projects. Open only to member companies of the three sponsors.

PROGRAMS

The Lab for Education & Application Prototypes (LEAP): Located in MIT.nano's fifth floor prototyping space, this facility contains advanced tools for packaging integrated photonics. LEAP is a collaboration with the MIT AIM Photonics Academy, the education and workforce development arm of the AIM Photonics Institute, one of 14 Manufacturing USA institutes launched as part of a federal initiative to revitalize American manufacturing.

The MIT-Monterrey Tec Program: A collaboration with Tecnológico de Monterrey of Mexico, one of Latin America's largest universities, this exchange program brings Tec students and faculty to Cambridge for fellowships, internships, and research stays in MIT labs and centers.

MIT.nano Director Vladimir Bulović, the Fariborz Maseeh (1990) Professor of Emerging Technology, introduces the Dresselhaus Lecture to an audience of students, staff, and faculty at MIT.

STUDIO.nano: A platform for artistic collaboration at the intersection of technology, science, and art, rooted in the facilities and toolsets of MIT.nano. STUDIO.nano organizes exhibitions and symposia, and serves as a hub for connections between artistic practice and the frontiers of advanced materials, computing, virtual reality, artificial intelligence, and other disciplines.

SEMINAR SERIES

Mildred S. Dresselhaus Lecture: An annual lecture honoring a luminary in nanoscience and nanotechnology, named for Institute Professor Mildred Dresselhaus.

MIT.nano Seminar Series: Talks by prominent researchers from inside and outside MIT and across the spectrum of nanoscale science and engineering.

IMMERSED: A seminar series presented by the MIT.nano Immersion Lab exploring immersive technologies and new frontiers for manipulating and understanding data.

Nano Explorations: Presentations on current research by MIT students and postdocs from the MIT.nano user community.

Tool Talks: Introductions to the latest tools, instruments, and methods through talks and demos presented by equipment providers and technique experts.

START.NANO: MIT.NANO'S HARD-TECH ACCELERATOR

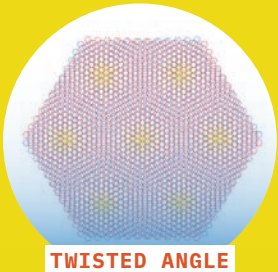
START.nano offers discounted access to MIT.nano's facilities and other benefits to promising hard-tech ventures.

The goal of START.nano is to minimize the cost of launching a nascent idea, helping increase the survival rate of these early-stage ventures and shortening the time it takes for their innovations to reach the market.

Participating startups have access to tools and other advantages that can help them create more well-developed prototypes, obtain validated data, set them on the path success, and position them for the next stage of growth.

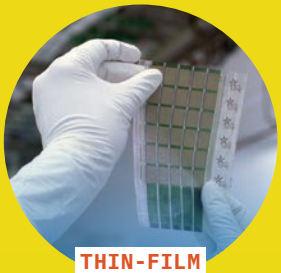
The founders of Active Surfaces, a START.nano venture developing ultra-lightweight photovoltaics, celebrate winning the 2023 MIT $100K Entrepreneurship Competition.

GAME-CHANGING RESEARCH, WORLD-CHANGING IMPACT



TWISTED ANGLE GRAPHENE

Pablo Jarillo-Herrero
Physics

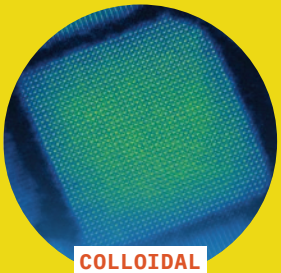


THIN-FILM PHOTOVOLTAICS

Vladimir Bulović
Electrical Engineering & Computer Science

HYDROPHOBIC SURFACES

Kripa Varanasi
Mechanical Engineering

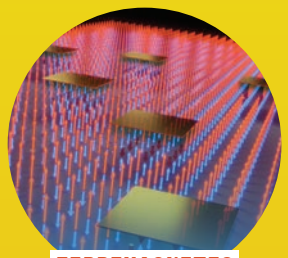


COLLOIDAL NANOCRYSTALS

Moungi Bawendi
Chemistry

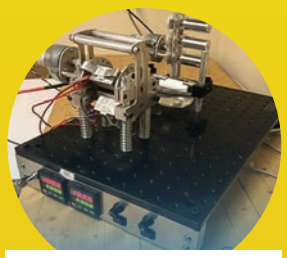
2D LIGHTWEIGHT POLYMERS

Michael Strano
Chemical Engineering



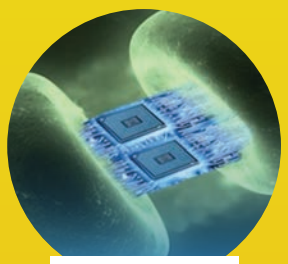
FERRIMAGNETIC MATERIALS

Bilge Yildiz
Nuclear Science & Engineering



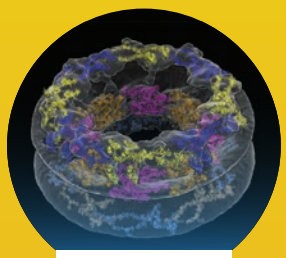
TRANSPARENT GRAPHENE ELECTRODES

Tomás Palacios
Electrical Engineering & Computer Science



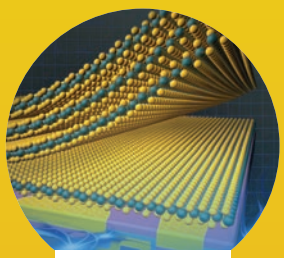
HUMAN-MACHINE SYMBIOSIS

Deblina Sarkar
Media Arts & Sciences



NUCLEAR PORE COMPLEX

Thomas Schwartz
Biology

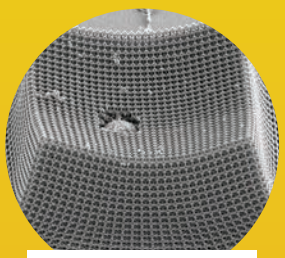


NANOELECTRO-MECHANICAL SWITCHES

Farnaz Niroui
Electrical Engineering & Computer Science

BIO-INSPIRED MATERIALS

Benedetto Marelli
Civil & Environmental Engineering



NANO-ARCHITECTED MATERIALS

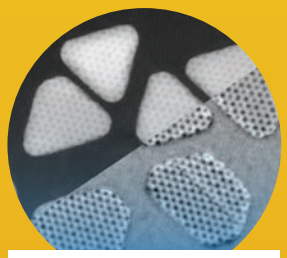
Carlos Portela
Mechanical Engineering

DIAMOND PHOTONICS

Dirk Englund
Electrical Engineering & Computer Science

VR-ELECTROCARDIOGRAM

Elazer Edelman
Institute for Medical Engineering & Science



NANOSCALE MATERIALS

Frances Ross
Materials Science & Engineering

METALENS

Juejun Hu
Materials Science & Engineering

MIT students fabricate a 200mm wafer with the logo of the Northeast Microelectronics Coalition Hub (NEMC). MIT.nano is the core facility for this CHIPS Act funded regional network of 200+ companies, academic institutions, startups, and research centers.

PARTNERING WITH INDUSTRY

MIT's history of discovery and invention has taught us that a successful innovation ecosystem generates an enthusiasm for opening doors. We understand that innovation flourishes when people and ideas can flow across, through, and around organizations. And we believe that discovery, invention, and impact are all dramatically enhanced through corporate partnership across sectors and scales, from Fortune 500 companies to startups.

THE MIT.NANO CONSORTIUM

The MIT.nano Consortium is our platform for developing strategic relationships with large organizations. For our corporate collaborators, joining the potent culture of innovation at MIT.nano energizes their efforts and offers early insight into the technological advances that will help shape the world of tomorrow.

For MIT, industry partnerships bring us important intellectual problems, help speed new technologies to market, and focus our work for lasting, practical impact.

For member companies, the MIT.nano Consortium offers:

Awareness: Early insight into ideas and innovations emerging from MIT labs.

Connection: Guided relationships with the MIT community.

Talent: Recruitment from MIT's talented pool of students and alumni.

Collaboration: Cooperative engagement with MIT.nano and campus researchers.

Toolsets: Discounted access to utilize MIT.nano's facilities.

Customization: Direct a portion of your membership fee to the purpose of your choice.

MEMBERS:

- Analog Devices
- Applied Materials
- Edwards
- Fujikura
- IBM Research
- Lam Research
- Lockheed Martin
- NC
- NEC Corporation
- Shell
- Viavi Solutions

TO LEARN ABOUT MEMBERSHIP, CONTACT:

Kelly Gavin
MIT.nano Consortium Manager
kellygav@mit.edu

A representative from Viavi Solutions describes the company to MIT students at the MIT Deep Tech Career Fair, an annual recruitment event open only to MIT.nano Consortium members.

A researcher uses the Semilab SE-2000 Spectroscopic Ellipsometer at MIT.nano to characterize the properties of a thin-film of material deposited in the fab.

READY TO HELP BUILD A BETTER WORLD? CONNECT WITH US.

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