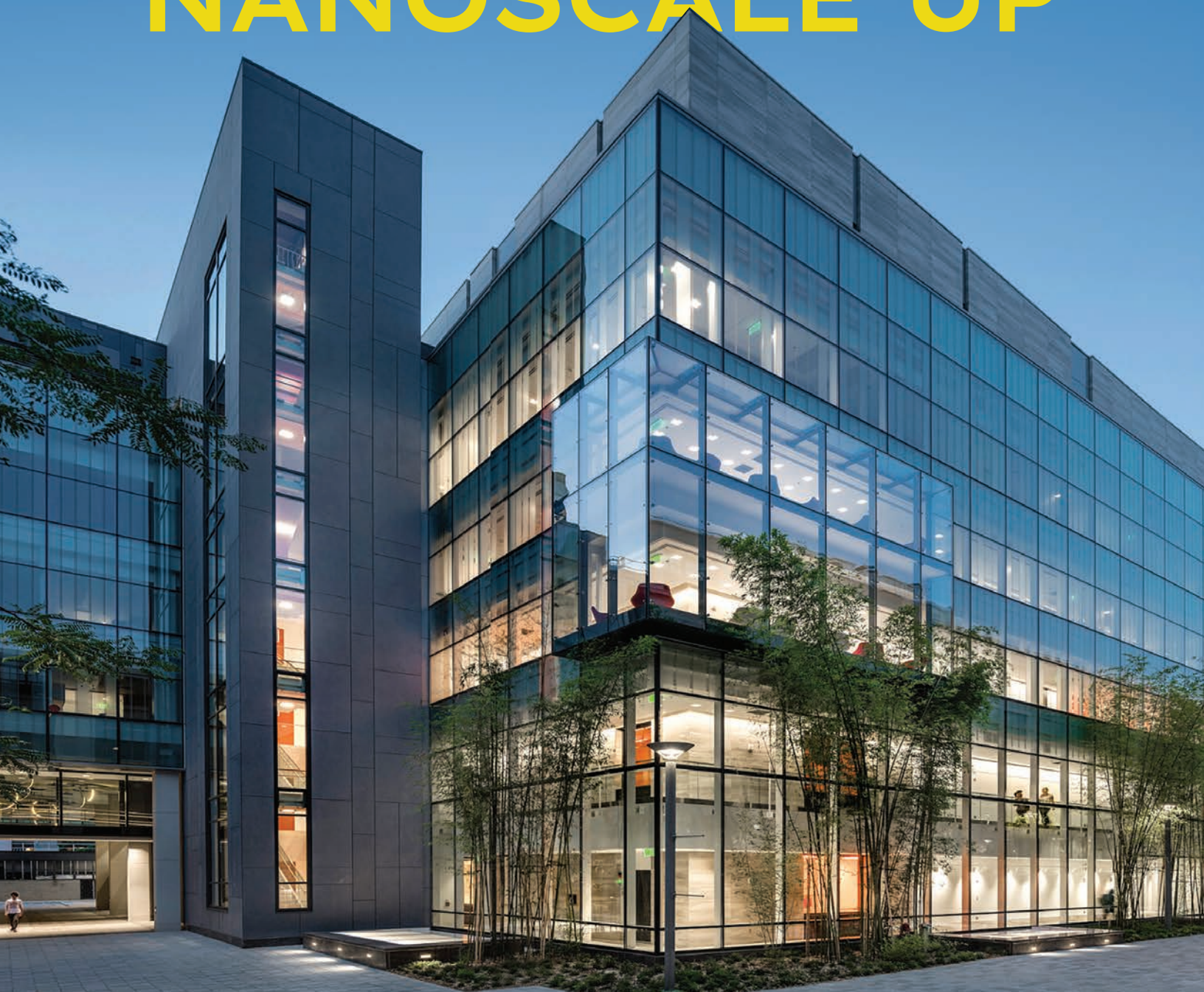
MIT.nano | **LISA T. SU BUILDING**
Building 12 at MIT

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. WE INVITE YOU TO STEP INTO THE NANO AGE.

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.

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

214,000 square feet in total, with 100,000 square feet of high-performance laboratory space and 50,000 square feet of Class 100/1000 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 nexus for cross-disciplinary problem solving, serving more than 130 PI laboratories drawn from over 30 MIT departments, labs, and centers.

A hub offering seminars, seed grants, exhibitions, conferences, startup support, and other programs that take advantage of our unique position to convene and 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.

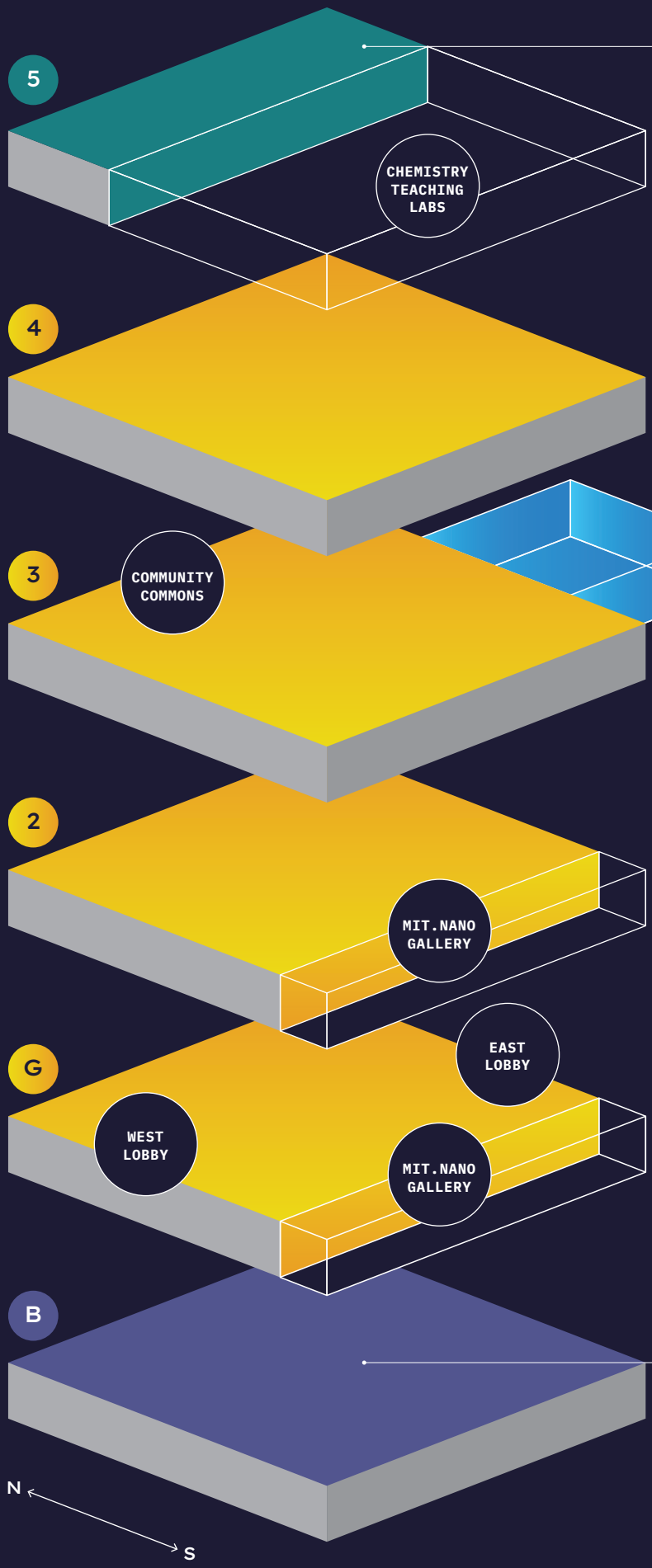
INNOVATION RADIATES FROM MIT OUT

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, 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

Four stories and 50,000 square feet of Class 100/1000 cleanroom facilities with comprehensive 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.

A research scientist developing organic thin film flexible photovoltaics in the NanoMat Solar Frontiers facility on the third floor.

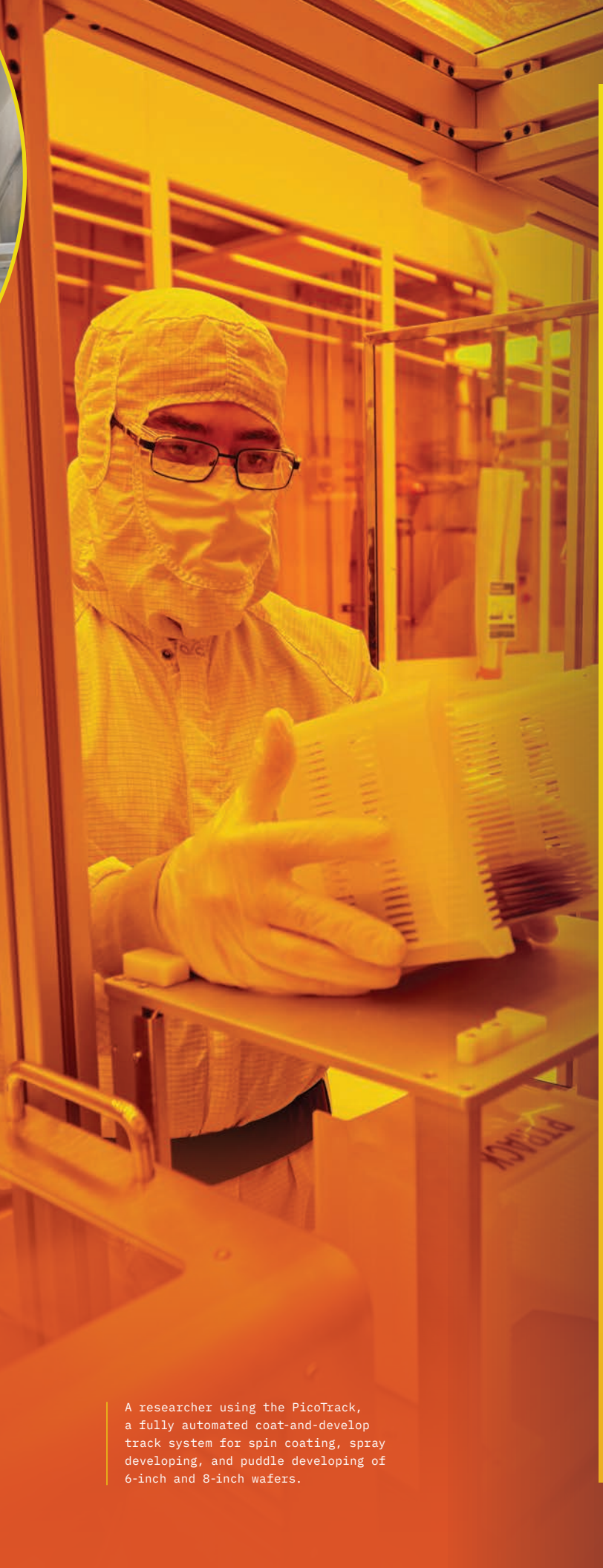
FABRICATION

The heart of MIT.nano is approximately 50,000-square-feet of Class 100/1000 cleanroom for the design, fabrication, and analysis of micro and nanoscale structures and devices.

This substantial area has the capacity to accommodate well over 1,000 qualified researchers annually. The size, sophistication, and sensitivity of the labs also enable us to incorporate a broad and growing 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 Class 100/1000/10000 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.

By August 2022 the cleanroom will contain 160 tools and instruments. Even with this substantial toolset, the facility will be at just 65 percent 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.



A researcher using 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.

Our tools support a wide spectrum of nanofabrication processes including:

LITHOGRAPHY

- Electron Beam Lithography
- Two Direct-Write Maskless Aligners
- Automated Wafer-Coater and Developer
- Two-Photon 3D Exposure System

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

- Applied Materials Reactive Ion Etcher (RIE)
- Three SAMCO Inductively Coupled Plasma Etchers (ICP)
- SPTS Pegasus Deep Reactive Ion Etcher (DRIE)
- Three Plasma Ashers, including Automated Wafer and Barrel ashers

DIFFUSION

- Annealsys Rapid Thermal Processing (RTP) tools
- Expertech Oxidation/Anneal Furnace

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)

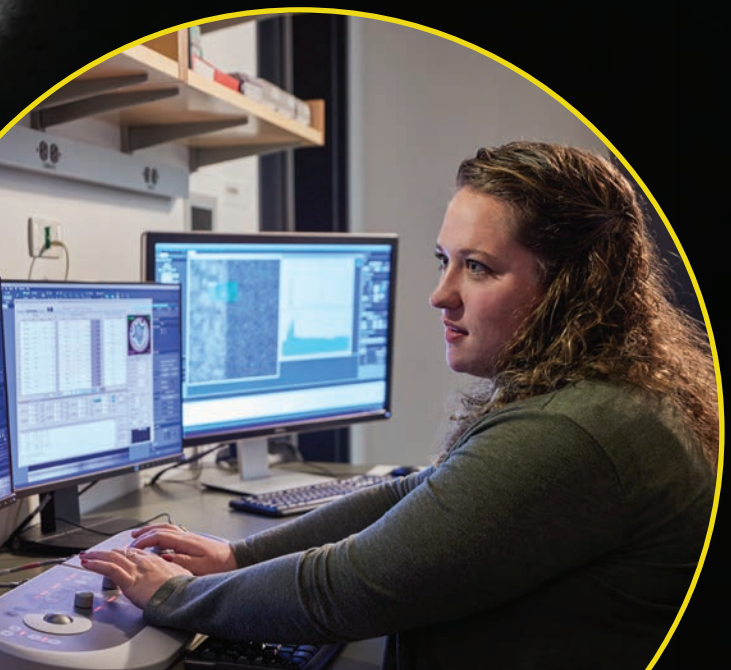
Individual moving atoms imaged using the Thermo Fisher Scientific Titan Themis Z G3 aberration-corrected scanning transmission electron microscope in MIT.nano's characterization facility.

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 twelve imaging suites are rated Vibration Criteria E & G. Each level is challenging to achieve; a VCG 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. In just the first year of full operation, 160 users from 12 different academic departments, plus external users from industry and other institutions, utilized our instruments to advance their investigations.

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.



AUTOMATED CRYOGENIC ELECTRON MICROSCOPY (CRYOEM)

MIT.nano's CryoEM tools enable automated electron imaging of cryogenically preserved specimens. These instruments are used to visualize the three-dimensional morphology of cellular components and structural details of macromolecules, organic nanoparticles, and other thin materials that are hydrated or sensitive to beam damage.

- Titan Krios G3i Cryo Transmission Electron Microscope
- Talos Arctica G2 Cryo Transmission Electron Microscope
- Aquilos Cryo Focused Ion Beam-Scanning Electron Microscope
- Cryo specimen preparation
  - Chameleon
  - Vitrobot Mark IV
  - EMITech K100

IMAGING AND ANALYSES

MIT.nano's microscopy instruments provide users with analytical platforms that offer high-resolution imaging modalities and unsurpassed versatility, enabling access to structural and chemical information from the micrometer to the sub-angstrom scale. These tools support visualization and quantification of atomic lattices, defects, structure, phase homogeneity, composition and more, as well as provide mechanistic insights on the origin of material properties.

- Titan Themis Z G3 Cs-Corrected Scanning Transmission Electron Microscope
- VELION Focused Ion Beam-Scanning Electron Microscope
- Gemini 450 Scanning Electron Microscope
- Cypher Video-Rate Atomic Force Microscope

CLEANROOM METROLOGY

MIT.nano's cleanroom metrology toolset is built with rapid characterization or process inspection in mind. Capabilities include optical and contact profilometry, spectroscopic ellipsometry, large area atomic force microscopy, UV-VIS optical characterization, fluorimetry, rapid electrical characterization, and thin film stress measurement setups.

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

As MIT's first open-access facility for immersive experiences and interacting with data, the Immersion Lab is where nano meets meta.

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, and developing software and hardware paradigms to deliver the coming metaverse.

The space 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 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. If a topic can be imagined, the Immersion Lab can help envision it in virtual reality and beyond.

MAJOR CAPABILITIES

The Immersion Lab's capabilities include:

- Teaching in immersive environments
- Visualizing complex and multi-dimensional datasets
- Creating and rendering immersive content
- Generating digital twins
- Capturing and tracking 3D motion
- Performing computationally intensive research
- Studying physiological movements
- Displaying and performing creative arts
- Melding the physical and the digital

MAJOR TOOLS

The Immersion Lab is outfitted with an embedded OptiTrack system that enables precise motion capture via real-time active, passive 3D tracking of objects, and full-body motion analysis with the associated software.

Complementing the built-in systems are stand-alone instruments that study data, analyze and model the physical world, and generate new, immersive content, including:

- Matterport Pro2 photogrammetric camera
- Lenscloud 360-degree photogrammetric scanner
- Oculus Quest and Quest 2 VR headsets
- HTC Vive Pro Eye headset
- Microsoft HoloLens 2 AR headset
- HP G2 backpack computers
- Ricoh Theta V and Z1 360-degree cameras
- HP Z8 data science workstation
- Dell Alienware gaming workstation

Virtual reality makes it possible for instructors to bring students to environments that are hard to access, either geographically or at scale.

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

SENSE.nano: A Center of Excellence focusing on nano-enabled sensors, sensing systems, and sensing techniques. SENSE.nano awards seed grants to MIT principal investigators and hosts an annual conference on topics such as advanced manufacturing, healthcare, smart infrastructure, and advanced machines and materials.

Microsystems Annual Research Conference (MARC): Co-sponsored by the MIT Microsystems Technology Laboratories (MTL), this annual event brings together MIT students, faculty, and members of industry to explore 100+ current research projects. Open only to member companies from the MIT.nano and MTL industry consortia.

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.

ARTS.nano: A platform for artistic collaboration at the intersection of technology, science, and art, rooted in the facilities and toolsets of MIT.nano. ARTS.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.

Public galleries on MIT.nano's first and second floors present exhibitions on research, artistic collaborations, and student and faculty creative projects.

SEMINAR SERIES

Mildred S. Dresselhaus Lectures: Our flagship annual lecture, honoring a technical luminary in nanoscience and nanotechnology and celebrating the life and legacy of the "Queen of Carbon," Institute Professor Mildred Dresselhaus (1930–2017).

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

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.

IMMERSED: A monthly seminar series, presented by the MIT.nano Immersion Lab, that explores how immersive technology and new modalities for manipulating and understanding data are shaping innovations across science, engineering, and art.

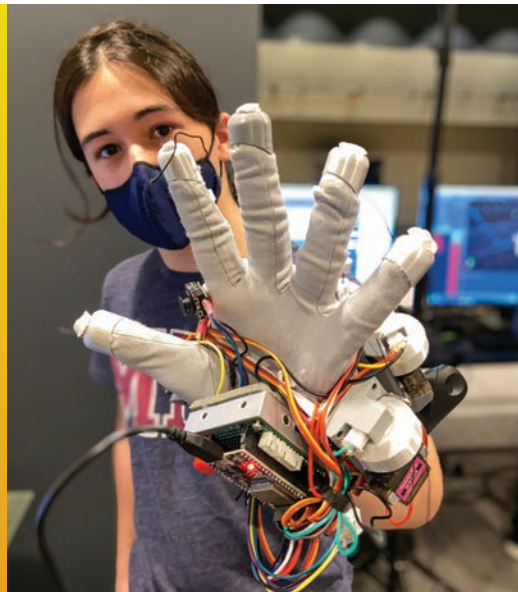
Nano Explorations: Presentations by MIT students and postdocs on their work in nanoscience, nanotechnology, and other advanced research fields. Initially conceived to keep the nano community connected during the pandemic, this series continues to join researchers and scientists virtually across the world.

Tool Talks: Introductions to the latest transformative technologies, tools, instruments, and methods presented by equipment providers and method inventors. These talks also include demonstrations in MIT.nano labs of new tools and techniques.

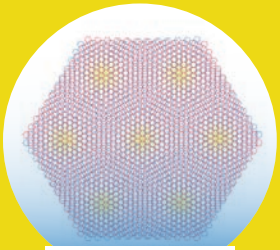
THE MIT.NANO IMMERSION LAB GAMING PROGRAM

A collaboration between MIT.nano and NCSOFT, this program seeks to chart the future of how people interact with the world and each other via hardware and software innovations in gaming technology. As part of the collaboration, NCSOFT, a video game development company and a founding member of MIT.nano, provided funding to acquire hardware and software tools to equip the MIT.nano Immersion Lab and offers annual seed grants to MIT faculty and researchers to foster hardware and software innovations in gaming technology.

The Immersion Lab supports explorations in both hardware and software, such as this student project to make affordable haptic gloves.



GAME-CHANGING RESEARCH, WORLD-CHANGING IMPACT

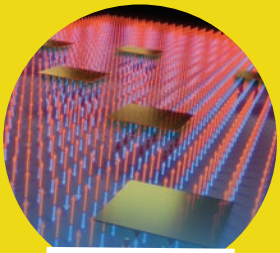


TWISTED ANGLE GRAPHENE

Pablo Jarillo-Herrero
Physics

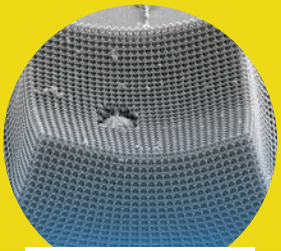
THIN FILMS

Vladimir Bulović
Electrical Engineering & Computer Science



FERRIMAGNETIC MATERIALS

Bilge Yildiz
Nuclear Science & Engineering

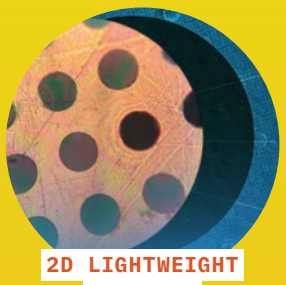


NANO-ARCHITECTED MATERIALS

Carlos Portela
Mechanical Engineering

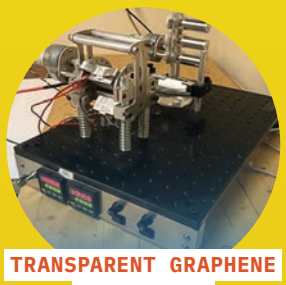
METALENS

Juejun Hu
Materials Science & Engineering



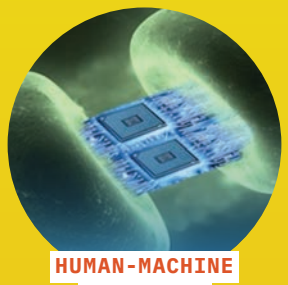
2D LIGHTWEIGHT POLYMERS

Michael Strano
Chemical Engineering



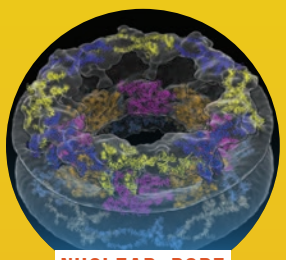
TRANSPARENT GRAPHENE ELECTRODES

Tomás Palacios
Electrical Engineering & Computer Science



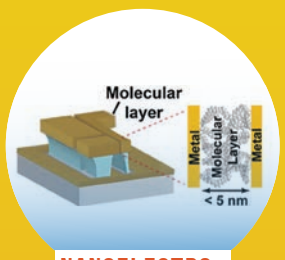
HUMAN-MACHINE SYMBIOSIS

Deblina Sarkar
Media Arts & Sciences



NUCLEAR PORE COMPLEX

Thomas Schwartz
Biology



NANOELECTRO-MECHANICAL SWITCHES

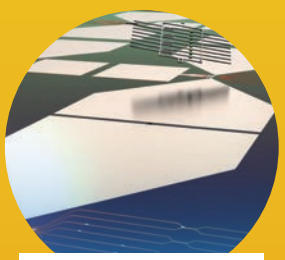
Farnaz Niroui
Electrical Engineering & Computer Science

BIO-INSPIRED MATERIALS

Benedetto Marelli
Civil & Environmental Engineering

ELECTROSTATIC LEVITATION

Paulo Lozano
Aeronautics & Astronautics

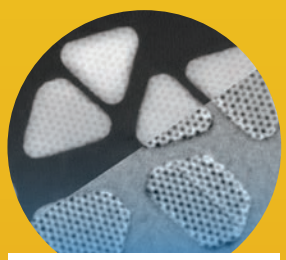


DIAMOND PHOTONICS

Dirk Englund
Electrical Engineering & Computer Science

VR-ELECTROCARDIOGRAM

Elazer Edelman
Institute for Medical Engineering & Science



NANOSCALE MATERIALS

Frances Ross
Materials Science & Engineering

HYDROPHOBIC SURFACES

Kripa Varanasi
Mechanical Engineering

An application scientist from Raith, a member company in the MIT.nano Consortium, collaborates with an MIT researcher using the Raith VELION FIB-SEM in our characterization facility.

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 program 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
- Draper
- Edwards
- Fujikura
- IBM Research
- Lam Research
- NCSOFT
- NEC Corporation
- Oxford Instruments Asylum Research
- Raith

START.NANO

Launched in 2021, START.nano is our hard-tech accelerator, offering discounted access to MIT.nano's capabilities to promising hard-tech startups.

The premise of START.nano is that early access to state-of-the-art laboratories can minimize the cost of launching a nascent idea, helping increase the survival rate of early-stage ventures and potentially 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 to success, and position them for the next stage of growth.

START.NANO COMPANIES ARE CONDUCTING RESEARCH IN:

- Chemical separations
- Sensors and sensing
- Integrated semiconductors
- Additive manufacturing
- Batteries & energy storage
- Neurotechnology
- Health and healthcare
- Photonics
- OLEDs
- Advanced fabrics
- Quantum computing
- Air conditioning
- Sustainable technologies

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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DESIGN Opus Design

MIT.nano