MSE CORE FACILITY

The Materials Science & Engineering Core Facility was officially commissioned in June 2012. Since that time, it has grown to house multiple core pieces of equipment for the Materials Science & Engineering and Photonics Center community. These include a materials processing area with two Salare hoods dedicated to acid and base processing; two Bruker X-Ray systems — the N8 Horizon and the D8 Discover for small- and wide-angle X-ray scattering (SAXS and WAXS), respectively; a Zeiss Xradia 410 Versa system for x-ray micro-tomography at sub-micron resolution; an AFM-FM microscope being retrofitted with Raman Spectroscopy for enhanced tip capability; a new Renishaw Raman microscope system with a heating/cooling stage and multiple wavelengths for Raman observation; a FEI Quanta 3D FEG FIB with dual SEM and FIB capabilities, and a FEI Tecnai Osiris S/TEM with EDX and EELS capabilities.

RESEARCH LABS

Advanced Materials Characterization Core Facility
Advanced Materials Process Control Lab
Applied Electromagnetics Lab
Atomic Membrane Lab
Campbell Group
Caradonna Group
Cell and Tissue Mechanics Lab
Coker Group
Computational Electronics Lab
Computational Energy Lab
Daniel Segre Lab
Dennis Lab
Doerrer Group
Engineering Materials for Energy and the Environment
Femtospec Lab
Green Manufacturing Lab
Grinstaff Lab
High-Temperature Chemical and Electrochemical Processing of Materials Lab
High Temperature Oxidation Lab
Integrated Photonics Lab
Interfacial Fluid Dynamics Lab
Lab for Engineering Education & Development
Lab for Diagnostics and Global Healthcare Technologies
Lab for Microsystems Technology
Lab for Organic Materials and Electronic Devices
Ling Lab
Materials Lab for Energy and Environmental Sustainability
Materials X-Ray Diffraction Lab
Matrix Mechanotransduction Lab
Mechanics of Slender Structures
Mesoscale Soft Matter Lab
Microscopy Lab
Multifunctional Materials Spectroscopy Lab
Multiscale Laser Lithography Lab
Multiscale Tissue Biomechanics Lab
Nano Heat Transfer Lab
Nanomedicine and Medical Acoustics Lab
Nanometer Scale Engineering Laboratory
Nanoscale Energy-Fluids Transport Lab
Nanostructured Fibers and Nonlinear Optics Lab
Novel Materials Lab
Optical Characterization & Nanophotonics Lab
Orthopaedic & Developmental Biomechanics Lab
Powder Metallurgy & X-Ray Lab
Precision Engineering Research Lab
Restorative Sciences and Biomaterials Lab
Semiconductor Photonics Research Lab
Sharifzadeh Group
Solid State Research Lab
Straub Group
Surface Modification Lab
Tien Group
Tsui Lab
Ultrafast Nanostructure Optics Lab
Ultrafast Optics Lab
Vibrations Lab
Wong Lab

For more information about each lab, go to www.bu.edu/eng/departments/mse/research/mse-research-laboratories/

RESEARCH CENTERS

BioMolecular Engineering Research Center
BU Nanotechnology Innovation Center
Center for Space Physics
Fraunhofer Center for Manufacturing Innovation
Neurophotonics Center
Neuromuscular Research Center
Photonics Center
Smart Lighting Engineering

ENGINEERING PRODUCT INNOVATION CENTER (EPIC)

With the addition of a metal-printing machine donated by GE, the College of Engineering will remain on the cutting edge of education and research in product design and manufacturing.

BOSTON

Boston is one of the most vibrant cities in America, an international hub for technology, industry and academia, and a sophisticated metropolitan area with many opportunities for enrichment and recreation. Boston is the ideal location for advanced engineering study to impact health care, technology, biotech, telecommunications, energy and more.

ALUMNI

"I am a Technical Product Manager at Verizon. I lead a team of 30 developers, UI designers, and scrum masters to build smart cities solutions using Internet of Things technology. I specialize in managing and developing products to reduce traffic and car crashes. I have helped Boston, Palo Alto, and the Washington Redskins to address traffic and road safety issues. Prior to Verizon, I was the first employee of Shell TechWorks, Shell Oil's Innovation Center in Boston. I helped to raise $2 million in funding and grew the office from 3 employees to 70 employees in 3 years.

MSE is the best program to find your own interest, hone your skills, and succeed. MSE allowed me to find advisors in almost all the disciplines at College of Engineering and College of Arts and Sciences at BU. I was exposed to a lot of new ideas and cutting-edge technologies. This exposure taught me to see things from a different perspective. The analytical and time management skills learned at MSE are life-long tools for success in my career."

— Nancy Ranxing Li (MSE PhD, 2013) Technical Product Manager, Verizon

"At Battery Resourcers, we are developing a novel Li-ion battery recycling project capable of recovering all the components of a Li-ion battery, including the cathode materials. Our process can recycle any Li-ion battery regardless of its size, shape or cathode chemistry. As CEO, I am responsible for the technical development of our process as well as any business dealings and fundraising. While conducting my PhD research in the Division of Materials Science & Engineering at BU, I worked directly with a startup. That experience is incredibly valuable in my current position."

— Eric Gratz (MSE PhD, 2012) Co-Founder/CEO, Battery Resourcers

CAREER PLACEMENT

Graduates from Boston University's MSE program are well-trained to make an impact in careers of constant innovation in emerging areas like nanomaterials, biomaterials, photonics, electronics, biotechnology, energy and plastics industries. Recent graduates have found success with pioneering corporations and in influential positions in academia such as:

- Honda
- Sensata Technologies
- Carnegie Mellon University
- Samsung Electronics
- Corning
- MIT
- Lockheed-Martin
- Fraunhofer Center for Manufacturing Innovation
- Johns Hopkins University
- Shell Oil
- Lam Research
- MOxST
- LiquiGlide
- Colgate Palmolive
- Swiss Federal Institute of Technology in Lausanne
- City University of New York
- Raytheon
- 3M
- Google
- WPI
- Harvard University

MSE AT A GLANCE

ACADEMIC DEGREES
PhD, MS, MEng

FACULTY
Appointed Faculty: 45
Affiliated Faculty: 36

STUDENTS IN FALL 2017*
Doctoral: 35
MS: 46
MEng: 13
LEAP: 9

ALUMNI: 142

DEGREES GRANTED SINCE 2008
Doctoral: 29
Masters: 64
Masters With Practice: 2**
MEng: 41***
Minors: 6***

** expected*
*** Masters With Practice was first offered in Fall 2014.*
**** MEng and Minor were first offered in Fall 2011.*

ON THE COVER

Professor Allison Dennis creates quantum dots to monitor the efficacy of chemotherapy drugs. The quantum dots, which utilize nanoparticle sized amounts of semiconductor metals, exploit the quantum physics concepts of photon absorption and emission to create particles in solution that can give off different wavelengths of light after excitation with UV light. Professor Dennis plans to use these quantum dots, which she hopes to make non-toxic with photon emissions in the near-infrared range, to perform molecular phenotyping of breast cancer.

Top photo: Dennis Lab members in front of a chemical fume hood used for colloidal synthesis. (left to right) Reyhaneh Toufanian (MSE, MS 2015; MSE PhD anticipated 2020), Thuy Nguyen (BME, BS 2015), Professor Allison Dennis, and Alexander Saeboe (MSE PhD anticipated 2020).

Bottom photo: A UV flashlight lights up vials of semiconductor quantum dots.

To learn more about the Dennis Lab, go to sites.bu.edu/dennislab.

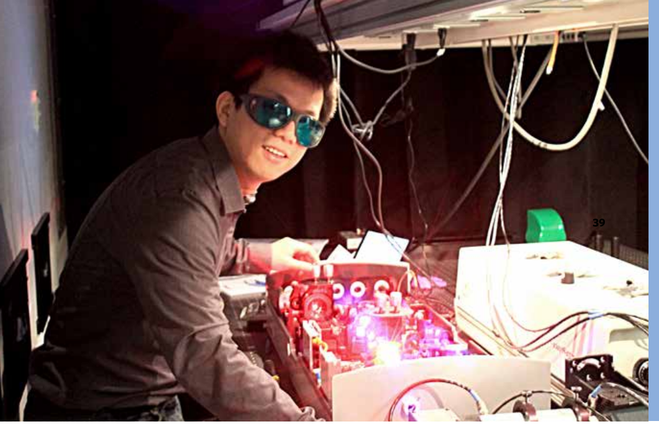
Boston University
College of Engineering
Division of Materials Science & Engineering

www.bu.edu/mse

BOSTON UNIVERSITY
Boston University College of Engineering
Division of Materials Science & Engineering

RESEARCH AND GRADUATE PROGRAMS IN

MATERIALS SCIENCE & ENGINEERING



GRADUATE PROGRAMS

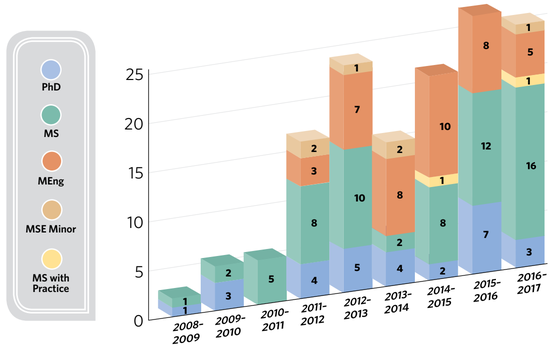
Doctor of Philosophy (PhD) Programs
Post-bachelor's PhD
Post-master's PhD
Through coursework, collaborative training projects and dissertation research, MSE PhD students learn to apply analytic and advanced computational methods and the latest techniques to current problems in biotechnology, nanotechnology, electronic and photonic devices, energy processing and more. Research areas include clean energy, solid-state lighting, photonics and fiber optics, biomaterials and soft tissues, and MEMS and bioMEMS applications.

Master of Science (MS)
The Master of Science (MS) degree in Materials Science and Engineering offers thesis and non-thesis tracks that prepare students for a research-focused career creating ground-breaking applications for new materials and modifications of existing ones. A variety of fields are open to well-trained materials science researchers, including energy, health care, information technologies and homeland security.

Master of Engineering (MEng)
The non-thesis Master of Engineering program is suited to industry professionals who wish to further their careers by acquiring deep technical knowledge, supplemented with business fundamentals and critical management skills. The degree program can be completed in as little as one year of full-time study (part-time study is also an option), and students may concentrate in biomaterials; materials for energy and environment; electronic/photonic materials; or nanomaterials.

Masters With Engineering Practice
Any masters student interested in the With Engineering Practice option must apply and complete an approved internship integral to their program of study. This degree option allows a student to develop additional technical and professional skills.

NUMBERS OF DEGREES AWARDED



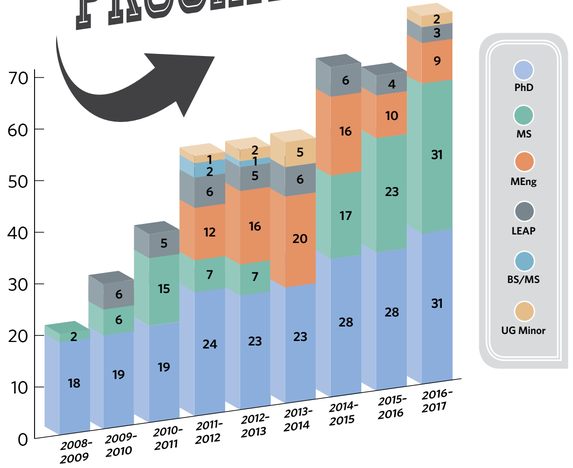
MESSAGE FROM THE DIVISION HEAD

Welcome to the Boston University Division of Materials Science and Engineering Annual Report Highlights. In this brochure you will see the astonishing growth of our program since its inception nine years ago. Here also is a small sampling of the amazing breadth and depth of research being done in Materials Science at Boston University, ranging from studies of the mechanical properties of human bone to nano-mechanical devices working at the quantum limits to deep UV sources to provide enough clean drinking water for the world's thirsty inhabitants. Researchers at BU are pushing the frontiers of science and engineering and in doing so creating technologies that are positively impacting the lives of people around the world, and making the world a better place for us all.

I am proud of the MSE program and the research of my colleagues, and urge you to visit our website at **www.bu.edu/mse** to learn more.

— *Dave Bishop,* Head, BU MSE

PROGRAM GROWTH



FALL 2017 QUANTITATIVE MEAN GRE SCORE

165

MATERIALS SCIENCE AND ENGINEERING AT BOSTON UNIVERSITY

Boston University's Division of Materials Science and Engineering is at **the forefront of creating breakthroughs in our understanding and use of novel materials to solve society's most pressing technological challenges.** The strong link between materials science, emerging research, and products in the marketplace means ample job opportunities and a positive career outlook for materials scientists and engineers with advanced academic training. Learn more about the innovations taking place at **www.bu.edu/mse.**

IN FY 2017
MSE RECEIVED
$8.6 MILLION
IN NEW RESEARCH FUNDING, AND HAD ON-GOING RESEARCH FUNDING OF
$52 MILLION

MAJOR RESEARCH AREAS

Biomaterials research encompasses areas such as tissue engineering, design of biomolecules and biopolymers, biosensors, laser spectroscopy and more to create innovations in health care. Over the last decade exciting developments in materials-based technologies range from lab-on-a-chip devices to drug delivery systems to novel engineered tissues.

Electronic and photonic materials research is invested in III-V nitrides, carbon nanotubes, fiber optic sensors, quantum dots and computational modeling. Engineering breakthroughs—like the blue LED—were produced by Boston University labs and interdisciplinary researchers continue to explore myriad applications in such areas as health care, national defense and information systems.

Materials for energy and environment can help produce cleaner and more efficient sources of energy to address our present energy-related concerns and steer society to a more sustainable future. Active research areas include clean energy conversion, hydrogen generation and storage, fuel cells, green manufacturing and biofuels/metabolics.

Nanomaterials research is concentrated in areas such as coatings, composite materials, photo-acoustic microscopy, nanoscale materials, and multi-scale modeling. Research, often conducted with industry partners, spans a range of application areas, including mechanics and fluid dynamics at the nano-scale, and developing enhanced materials processing capabilities for opto-electronic applications, advanced engines and power systems.

OUR HIGHLY SUCCESSFUL AND INTERNATIONALLY RECOGNIZED FACULTY ARE DOING EXCITING RESEARCH...

Nanoscale 3D Printing Enables Bioelectronic Medicine Research

Professor Alice White has utilized nanoscale 3D printing to facilitate bioelectronics studies of individual nerves. The nanoclip, which she and her team designed for researchers investigating nerve activity of songbirds, addresses many of the challenges associated with studying small-diameter nerves. With the nanoclip, researchers can stimulate and record neural activity of small nerve fibers without damaging them and creating inaccurate measurements. White believes that these nanoclips could also be utilized in optical sensing and optogenetics.

Greater Than the Sum of Their Parts

Professor Jillian Goldfarb and Chitanya Gopu, a student researcher in her lab, are turning municipal solid waste into energy and activated carbons that could be used to treat the runoff from landfills. This process would create sustainable energy and useful materials from what would otherwise be simply trash. When working with students, Goldfarb strives to help the student grow into her own as a scientist, while Goldfarb provides support, knowledge, and experience.

Oil and Water

Professor James Bird and his research group revisited the relationship between gravity and surface tension in the capillary displacement of liquids with different viscosities in their study recently published as the cover article of *Langmuir.* Their results demonstrate that, contrary to previous belief, for some liquids, gravity has a role even in the early stages of capillary rise. This insight into capillary action is profound and has applications in a variety of problems, including oil recovery from contaminated water and industrial settings. They will continue to expand their research, investigating the effect of obstacles on this dynamic.

Off the Beaten Path

Professor Muhammad Zaman's research into the mechanical properties of tumor cells, featured as the cover article of *Biophysical Journal*, investigates the effect of the extracellular environment on the activity of YAP/TAZ, protein molecules that activate cell growth, proliferation, and apoptosis. He found that a stiffer extracellular environment directly increased intracellular YAP/TAZ activity, promoting cancer progression. Zaman and his team also developed an algorithm to predict YAP/TAZ activity in response to environmental changes, enabling researchers to predict the effect of physical environments and drug treatments on YAP/TAZ and thus cancerous growth and metastasis.

BU College of Engineering ranks 11th in research dollars expended per faculty member by the U.S. News & World Report.

BU Joins Federal Effort to Engineer Human Tissue: New national institute will develop innovative, life-saving industry

Professor David Bishop is coordinating Boston University's participation in the Advanced Regenerative Manufacturing Institute (ARMI), in an effort to further new ways of using living cells to construct tissues and organs. Several materials science and engineering professors' research could be integral to BU's part in making engineered human tissue a reality. Professor Thomas Bifano's high-resolution imaging research would allow a look deep inside tissue, and Professor Christopher Chen's world-renowned expertise in regenerative medicine would be invaluable. In the end, this project could usher in a new era of manufacturing in the United States: tissue manufacturing.

Metamaterials: Tuning into Long-Wavelength Light

Professor Xin Zhang and her team recently published a paper in *Microsystems and Nanoengineering*, a *Nature* journal, outlining the creation and properties of an artificial material with electrical voltage-dependent optical properties. Their metamaterial, comprised of two arrays of incomplete rings, could manipulate the intensity and phase of terahertz radiation transmitted through the metamaterial. The changes in the metamaterial are induced by a microelectromechanical system suspended in the metamaterial's substrate. Because many chemicals exhibit unique terahertz spectral fingerprints, this metamaterial could be utilized to increase the sensitivity of detecting a variety of chemicals, including explosives, pharmaceuticals, and biomolecules.

A Better Way to Treat Burns from BU's Grinstaff Lab

Professor Mark Grinstaff's group is developing a hydrogel burn dressing that would make the treatment of severe burns easier and less painful. The hydrogel acts as a barrier to infection, keeps the wound moist, and can be washed off painlessly, as opposed to the painful and lengthy process currently required to change bandages on patients with second and third degree burns. This is especially useful for re-bandaging children, where it would eliminate the need to anesthetize young patients for the re-bandaging process. Already successful in trials with smaller animals, the hydrogel will soon be tested on larger animals and then in clinical settings.

Emphysema: A New Way to Predict Treatment Outcomes?

Professor Bela Suki and his student Jarred Mondonedo developed a computer model of emphysema that could help predict patient outcomes and personalize treatment. Their model builds off of Suki's previous work studying and modeling the properties of lung tissue as interconnected springs and lets them predict the effects of different interventions at different points in the progression of the emphysema. Some of the treatments they compared include bronchoscopic lung volume reduction and traditional lung volume reduction surgeries. They hope their model can help physicians and patients select the optimal treatment plan on a case-by-case basis.