ADVANCED MANUFACTURING

UNIVERSITY OF TORONTO | Engineering

ADVANCED MANUFACTURING RESEARCH AT U of T ENGINEERING

We live in a material world. Modern industries are demanding more from materials than ever before. With advances in artificial intelligence, robotics, automation, and a move toward low-volume, high-value products, the way we process and create consumer goods is evolving.

Research and educational programs at U of T Engineering are creating next-generation technology for advanced manufacturing while preparing future engineers to lead in industry. We are developing more efficient processes for extracting resources, customizing the design of materials and processes, and optimizing distribution networks for large, complex operations. These insights impact every stage of the manufacturing value chain.

Manufacturing remains one of the key drivers of the economy — in Ontario, Canada and around the world. By enabling industry to do more with less, our advanced manufacturing experts are enhancing global prosperity, reducing our environmental impact and improving quality of life.

SELECTED AREAS OF EXPERTISE IN ADVANCED MANUFACTURING RESEARCH AT U of T ENGINEERING

- Advanced Aerospace Structures
- Advanced Coating Technologies
- Cellular Hybrid Materials
- Human-Machine Interaction
- Intelligent Decision Engineering
- Laser Photonics Fabrication
- Maintenance Optimization & Reliability Engineering
- Microcellular Plastics
- Multifunctional Lightweight Structures
- Nanomaterials
- Organic Optoelectronics
- Robotics & Automation
- Smart & Multifunctional Materials

SELECTED EDUCATIONAL OFFERINGS IN ADVANCED MANUFACTURING

Our Master of Engineering students can choose from a wide range of technical emphases including Advanced Manufacturing, while all engineering graduate students have the option of pursuing a Robotics & Mechatronics emphasis. Undergraduates in the Engineering Science program can major in Robotics, while students in our core engineering disciplines can pursue minors in Advanced Manufacturing and Robotics.

RESEARCH CENTRES & INSTITUTES

2014

TORONTO INSTITUTE OF ADVANCED MANUFACTURING (TIAM)

TIAM expedites the research and development of advanced manufacturing technologies by creating a multidisciplinary network focused on sharing knowledge, ideas and resources. The Institute is a global leader in translating lab-based technologies into scaled-up processes and by contributing to the education of highly qualified personnel in the manufacturing sector.

2012

ONTARIO CENTRE FOR THE CHARACTERIZATION OF ADVANCED MATERIALS (OCCAM)

This multidisciplinary facility provides leading-edge equipment — including electron microscopes and mass spectrometers — and expertise in the imaging, analysis and manipulation of materials at the nanometre scale. OCCAM was created with strategic investments from the Canada Foundation for Innovation (CFI), the Ontario Ministry of Research and Innovation (MRI), and Hitachi High-Technologies Canada.

2010

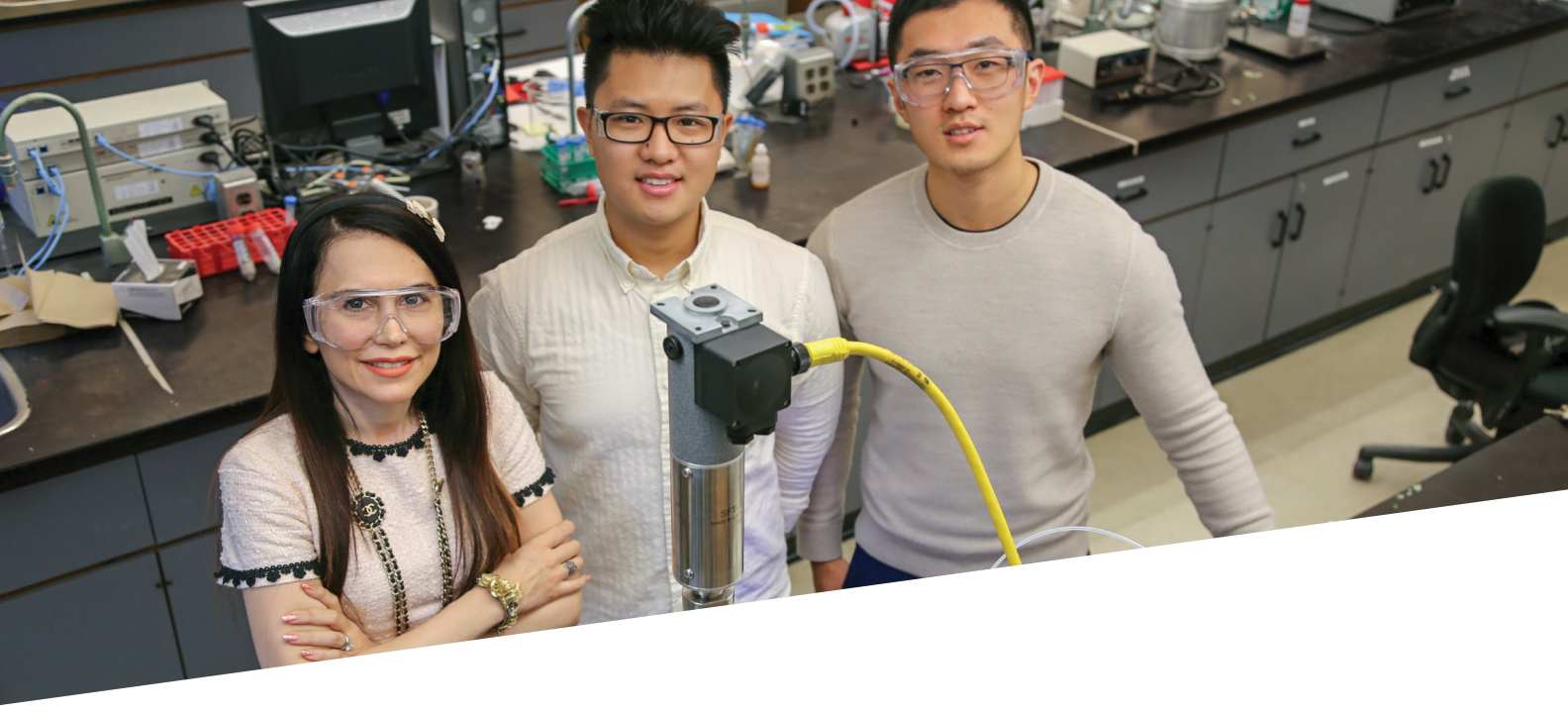
INSTITUTE FOR ROBOTICS & MECHATRONICS (IRM)

IRM brings together more than 50 principal investigators from across U of T Engineering and the Department of Computer Science to create the next generation of intelligent and autonomous robots for use in a variety of sectors: manufacturing, exploration, rescue, security and more.

1998

CENTRE FOR ADVANCED COATING TECHNOLOGIES (CACT)

A collaboration between the Departments of Mechanical & Industrial Engineering and Materials Science & Engineering, CACT conducts fundamental research in the area of thermal spray coating. It contains facilities for atmospheric plasma spray (APS), high velocity oxy-fuel spray (HVOF), wire-arc spray, and radio-frequency inductively coupled plasma (RF-ICP) and vacuum plasma spray forming (VPSF). Industrial collaborators include BMW USA, Pratt & Whitney Canada, TeckCominco and the National Research Council's Industrial Materials Institute.



RESEARCH IMPACT

"Our research and educational programs cover the entire manufacturing sector, from engineering to management to logistics. Our goal is to enable existing companies to innovate and improve, and to support the development of new businesses that don't exist today."

PROFESSOR HANI NAGUIB
Director, Toronto Institute of Advanced Manufacturing (TIAM)

RECOVERING RARE-EARTH ELEMENTS FROM E-WASTE

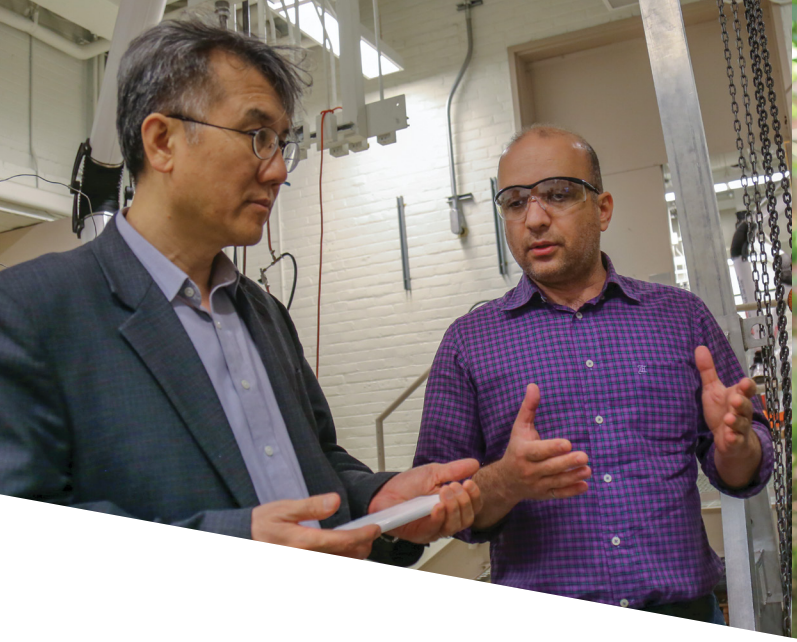
A retired smartphone languishing in a drawer may seem worthless but, from a materials point, it is a gold mine. Jointly appointed to the Departments of Chemical Engineering & Applied Chemistry and Materials Science & Engineering, Professor **GISELE AZIMI** (left) and her team are developing new methods for recovering strategic materials—including rare-earth elements—from disused electronics and other forms of waste.

Rare-earth elements are used in magnets and batteries, and growing demand for both consumer electronics and electric vehicles is causing prices to rise faster than new mines can be developed to supply them. Now various industries are looking at non-traditional sources for these materials.

Azimi and her team are working with Nutrien, a major global producer of fertilizer, to develop techniques for extracting rare-earth elements from an industrial byproduct called phosphogypsum. They have also partnered with Rio Tinto Alcan to harvest rare-earth elements from a byproduct of the aluminum industry known as 'red mud.'

Current recycling techniques are energy-intensive. Azimi and her team have a different approach which can recover up to 90 per cent of the rare-earth elements contained in a nickel-metal-hydride battery. Future work will focus on growing this process from the lab to the industrial scale.

Through various projects, Azimi has also partnered with Tenova Goodfellow, Hatch, Potent Group, Mercedes Benz Research and Development North America, and H.C. Starck. In the past, she has also worked with Agrium, Vale, and GreenMantra Technologies.



INNOVATING MANUFACTURING PROCESSES WITH MICROCELLULAR FOAMS

No matter where they are built in the world, modern buildings rely on high-performance thermal insulation to keep the costs of heating and cooling manageable. For many years, mechanical engineering professor **CHUL PARK** (left) and his team have used their expertise in microcellular foams to reduce the cost of this insulation while maintaining its physical properties. Now, their research is pointing in new directions, from personal electronics to oil spill remediation.

Park and his team have pioneered manufacturing processes that produce foams with pores or cells that are smaller and more numerous than in traditional materials. This approach results in foams that trap more air and are therefore lighter and less costly to produce, yet still maintain their mechanical strength.

More recently, Park has partnered with NanoXplore, a company that manufactures graphene nanoplatelets. This carbon-based material conducts both heat and electricity very well, something that traditional plastics cannot do. Park, who is the Senior NSERC/NanoXplore Industrial Research Chair in Multifunctional Graphene-based Nanocomposites and Foams, is working to make hybrids of graphene and foamed plastic that would be extremely useful in sensors, smartphones and other portable electronic equipment.

Another project out of Park's lab involves using chemically modified foams that could help clean up oil spills or remediate tailings water produced by the oil sands industry.

Over the years, Park's lab has partnered with leading companies such as Autodesk, Arkema, Solvay, and SABIC.

BUILDING THE BARK BIOREFINERY

With 347 million hectares of forest land—about nine per cent of the world's total—Canada is a leader in the global forest products industry, from softwood lumber to newsprint. But many parts of the tree, such as the bark, are not currently used for any product; they are either burned for energy or discarded.

Chemical engineering professor **NING YAN**, an expert on the chemistry of wood and bark, hopes to change that. Her research focuses on developing sustainable bio-based chemicals and materials using renewable forest biomaterials as feedstock. The resulting materials would be greener than the current options, which are produced using fossil fuel-based processes.

In partnership with forest, agriculture, chemical, materials and automotive companies, Yan's lab is working to extract and convert forestry and agriculture residues to feedstock for the synthesis of several sustainable materials. In turn, these materials—which include adhesives, resins, polyols and light-weight engineered composites—generate higher economic value for the forest and agriculture sectors.

FPInnovations, Woodbridge Foam, Arclin, Huntsman Corporation, Resolute Forest Products and Tembec are among Yan's ongoing industry partnerships. She believes that strong partnerships with industry are critical to the success of her research—they catalyze the development of bio-based products and technologies that meet industrial application needs. These partnerships have also allowed her graduate students and post-doctoral fellows to contribute solutions to challenges faced by industry.

THE IMPACT OF ADVANCED COATING TECHNOLOGY: FROM AEROSPACE TO HEALTH CARE

Today's airplanes have the capability to fly nonstop from Toronto to Hong Kong—something unheard of 20 years ago. The reason for the improvement in fuel efficiency has a lot to do with advanced thermal-barrier coating technology, which allows engines to run at higher temperatures, resulting in better fuel efficiency.

Mechanical engineering professor **JAVAD MOSTAGHIMI** is improving and innovating coating technology, and is working alongside 10 companies, including Airbus Industries, Pratt & Whitney Canada, Bombardier and Liburdi, to improve fuel efficiency and advance the aerospace industry for years to come.

Mostaghimi, a Distinguished Professor in Plasma Engineering and founding Director of the Centre for Advanced Coating Technologies (CACT), is also applying his research to the health-care sector. The World Health Organization (WHO) has recognized health-care-associated infection as a major patient safety issue for developing countries, affecting hundreds of millions of people worldwide. In developing countries, the risk is up to 20 times higher than in industrialized countries.

Mostaghimi and his team have developed a simple and affordable antimicrobial copper coating technology to help combat the global challenge of hospital-associated infections. At the Hospital Nacional Cayetano Heredia in Lima, Peru, Mostaghimi has tested the effectiveness of copper coating on furniture in an outpatient clinic room and on other commonly touched surfaces to improve patient safety.

THE FUTURE OF ADVANCED MANUFACTURING

FACTORY OF THE FUTURE

Led by mechanical and industrial engineering professors **HANI NAGUIB**, **GOLDIE NEJAT** and **CHRISTOPHER BECK**, the Factory of the Future initiative will transform smart manufacturing by preparing leaders of tomorrow and enabling new product development.

The Factory of the Future will undertake projects across three strategic focus areas: robotics and automation, smart sensing systems, and human-machine collaboration. State-of-the-art labs in the Toronto Institute of Advanced Manufacturing (TIAM) and the Institute for Robotics & Mechatronics (IRM) will enable partner companies to collaborate and develop new technologies and processes. These processes will be piloted within an industry environment to determine feasibility across design, assembly, maintenance, repair and inspection functions.

Ultimately, the Factory of the Future will deliver manufacturing solutions that benefit industry and society at large while keeping the Canadian manufacturing industry and workforce globally competitive.

BOMBARDIER INVESTS IN TORONTO AEROSPACE HUB

Canadian aerospace giant Bombardier Inc. is helping to establish an aerospace research hub near Downsview Airport, in collaboration with the University of Toronto Institute for Aerospace Studies (UTIAS) and other local academic institutions.

The company will invest $1.5 million over five years to fund core research that is part of a consortium of industry and academic partners, including U of T, called the Downsview Aerospace & Innovation Research (DAIR). Starting in 2019, Bombardier is also investing $1 million over five years to set up new research centres at U of T and Ryerson University that will focus on acoustics and advanced interiors, respectively.

Continuing its longstanding industrial partnership with Bombardier, UTIAS is poised to lead new research initiatives through grants that support academic-industry collaboration. Professor **PHILIPPE LAVOIE**, an expert in turbulence and aerodynamics, is one of two U of T researchers who will work on noise reduction with Bombardier as part of the new UTIAS research centre.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

LEADING INNOVATION STARTS HERE

Connect with us to discuss how a partnership with U of T Engineering can benefit your organization:

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www.uoft.me/leadinginnovationstartshere

STATEMENT OF ACKNOWLEDGEMENT OF TRADITIONAL LAND
We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people and we are grateful to have the opportunity to work on this land.