MANUFACTURING THE FUTURE

U of T Engineering, along with its partners, has a rich history of patents and inventions. We create the next-generation materials, components and manufacturing processes that will drive tomorrow's economy. Our world-leading facilities test new ideas that have the potential to boost productivity, save money and reduce environmental impact. Whether you are a sector-leading company, a nimble startup or a visionary entrepreneur, U of T Engineering can deliver solution to help you succeed.

HERE'S WHAT PARTNERING WITH U OF T ENGINEERING DELIVERS:

- An inside track to breakthrough technologies
- Customized solutions to industrially relevant problems
- An extra spark of innovation to your company
- Collaboration with U of T Engineering's world-leading researchers, including top graduate students, undergraduate students and alumni

RESEARCH
IMPACT
EDUCATION
PARTNERSHIPS

UNIVERSITY OF TORONTO | Engineering

OFFICE OF THE VICE-DEAN, RESEARCH
FACULTY OF APPLIED SCIENCE & ENGINEERING
UNIVERSITY OF TORONTO

416-946-3038 | vdr@ecf.utoronto.ca
uoft.me/collaboration

RESEARCH IN FOCUS:

ADVANCED MANUFACTURING

CHALLENGE:

How can the Canadian manufacturing sector compete in the global marketplace?

SOLUTION:

Develop smarter manufacturing techniques.

UNIVERSITY OF TORONTO | Engineering

SMARTER MANUFACTURING

FOR A 21ST-CENTURY ECONOMY

Canadian manufacturing is evolving. Scientific advances have ushered in new materials and techniques that are revolutionizing how goods are produced. While traditional assembly and production are still important, companies are increasingly focused on how to create better products through smarter design, engineering and product development. It's no longer just about making things, it's about adding value across every aspect of the industry.

The University of Toronto's Faculty of Applied Science & Engineering is a hub of advanced manufacturing research. Our reputation as the top engineering school in Canada and one of the best in the world — as evidenced by years of global rankings — continues to attract leading thinkers, experts and innovators in areas like nanotechnology, multifunctional materials and laser photonics fabrication.

"U of T Engineering drives innovation through cutting-edge research and education — both of which will keep Ontario and Canada competitive in the advanced manufacturing sector worldwide."

PROFESSOR EDWARD H. SARGENT
Vice-Dean Research, U of T Engineering
Canada Research Chair in Nanotechnology

THE MANUFACTURING SECTOR AT A GLANCE

CANADA

- In 2014, the manufacturing industry had total sales of $621.7 billion across Canada
- Manufacturing accounts for 10 per cent of Canada's GDP
- 1.85 million Canadians (about one in 10 working Canadians) are employed by the manufacturing sector
- In 2014, a survey conducted by Canadian Manufacturers and Exporters found that 59 per cent of businesses said they planned to increase their investment in research and development over the next three years

ONTARIO

- In 2014, the manufacturing industry had total sales of $286.5 billion, 46 per cent of Canada's total
- Manufacturing accounts for about 12 per cent of Ontario's GDP
- Exports of just three kinds of manufactured products (motor vehicles & parts, mechanical equipment and electrical machinery) made up 46.7 per cent of Ontario's exports in 2014

THE POWER OF PARTNERSHIP

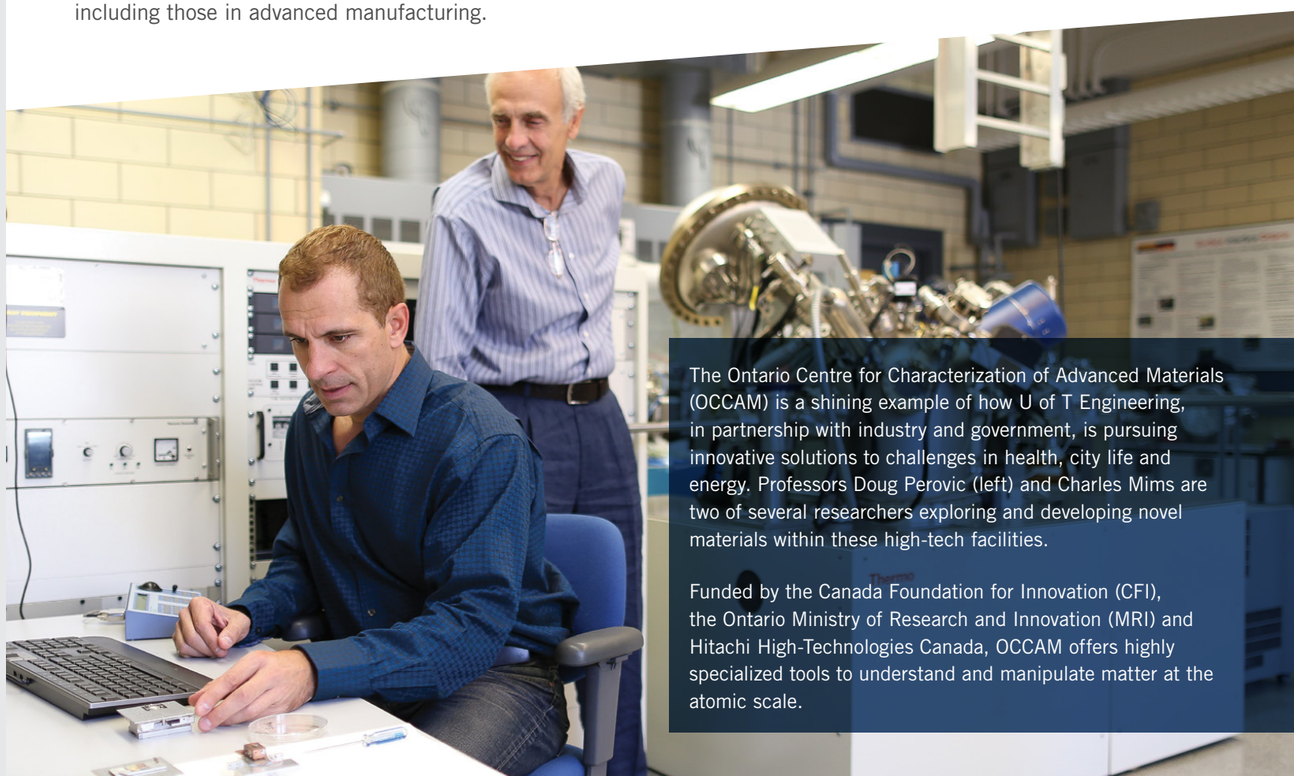
Our researchers work in state-of-the-art facilities such as the Ontario Centre for Characterization of Advanced Materials (OCCAM), and collaborate through innovative networks like the Toronto Institute of Advanced Manufacturing (TIAM), the Institute for Robotics & Mechatronics (IRM) and the Institute for Multidisciplinary Design & Innovation (UT-IMDI).

By working with leading researchers at U of T Engineering, manufacturing companies have access to cutting-edge research and development capabilities without the need to build up such capacity in house. This is especially important for small and medium-sized enterprises, many of which do not have the resources to test and optimize new techniques.

Through hands-on and collaborative research, U of T Engineering also trains engineering leaders of tomorrow. Our graduates are highly skilled, globally-aware citizens who will tackle society's biggest challenges, including those in advanced manufacturing.

U of T Engineering is uniquely positioned to make an impact in the Canadian manufacturing sector. We have a track record of success in working with industrial partners to overcome design challenges:

- $10.2 million in NSERC funding for Industrial Partnerships
- $8.4 million in direct funding from corporate partners
- Over 250 companies collaborating on engineering research, including: American Institute of Steel Construction, BMW, Celestica Inc., DuPont, Holcim, IBM, Proctor & Gamble, Toronto Hydro and Vale (to name a few)
- More than 300 invention disclosures in the last five years



The Ontario Centre for Characterization of Advanced Materials (OCCAM) is a shining example of how U of T Engineering, in partnership with industry and government, is pursuing innovative solutions to challenges in health, city life and energy. Professors Doug Perovic (left) and Charles Mims are two of several researchers exploring and developing novel materials within these high-tech facilities.

Funded by the Canada Foundation for Innovation (CFI), the Ontario Ministry of Research and Innovation (MRI) and Hitachi High-Technologies Canada, OCCAM offers highly specialized tools to understand and manipulate matter at the atomic scale.

TORONTO INSTITUTE OF ADVANCED MANUFACTURING

The Toronto Institute of Advanced Manufacturing (TIAM) at the University of Toronto is a new collaborative centre to enable technology in the 21st century. Headed by Professor Hani Naguib, Canada Research Chair in Smart and Functional Materials, TIAM provides the expertise and infrastructure to turn great ideas into better products. Through commercialization partnerships in Ontario and Canada, TIAM explores the cutting-edge technologies, materials and methods in advanced manufacturing that will help companies compete in the global marketplace.

Founded in 2014, TIAM has already made a tremendous impact in industry through collaborations with the likes of Celestica, Bombardier and GE Digital Energy. TIAM also supports research and development for smaller enterprises and startups.

TIAM HAS THREE STRATEGIC AREAS OF FOCUS:

1. ADVANCED MATERIALS

Traditional materials selected for a single property like strength (e.g., steel) are giving way to multifunctional materials that combine many properties at once. Nanoengineered materials made of assemblies of microscopic parts can be both light and strong. Natural materials like wood or other plant material can be made into composites for a more sustainable product.

2. ADVANCED PROCESSES

Instead of carving a part out of metal or plastic, advanced 3D printers can be used to build it up, one layer at a time. Known as additive manufacturing, this technique cuts down on waste, and allows a part to be tailored to the needs of a specific project. It's just one example of new processing methods that offer manufacturers greater creativity and flexibility to adjust their processes to respond to market forces.

3. KNOWLEDGE-BASED MANUFACTURING

As in many fields, the amount of data available on product quality, costs and market trends is increasing exponentially. Sophisticated computer models can mine this big data to identify inefficiencies and test out possible solutions. This knowledge-based approach allows managers to make smarter decisions about design and production.

As a multidisciplinary research hub, TIAM brings together: 17 U of T Engineering faculty members in 6 departments; 24 faculty members across Canadian universities; and 4 colleges in southern Ontario.

Core research areas include:

- Advanced Aerospace Structures
- Advanced Coating Technologies
- Cellular Hybrid Materials
- Hydrometallurgy
- Intelligent Decision Engineering
- Integrative Biology
- Laser Photonics Fabrication
- Microcellular Plastics
- Multifunctional Lightweight Structures
- Nanomaterials
- Organic Optoelectronics
- Robotics & Automation
- Smart & Multifunctional Materials

"TIAM strives for global leadership by translating lab-based technologies into commercial, scaled-up processes and by contributing to the education and training of highly qualified personnel in the manufacturing sector," says Professor Hani Naguib, Director of TIAM. Naguib (left) demonstrates the use of a mini lab for new product prototyping with graduate students Nazanin Khalili and HaoTian Harvey Shi.

TRAINING TOMORROW'S MANUFACTURING LEADERS

In a recent article in *The Hill Times*, Peter Lortie, President of the Canadian Academy of Engineering, said:

"Collaborative R&D between universities, research establishments and industry, is an essential ingredient... Educational establishments should also play a proactive role in bridging the gap between education and work by forming closer relations with local manufacturing companies, and embracing apprenticeships."

This is precisely the philosophy behind several of U of T Engineering's unique educational offerings directly tied to manufacturing.

For example, U of T graduate students pursuing a Master of Engineering (MEng) can select the newly created Advanced Manufacturing stream. This academic emphasis is part of TIAM's educational mandate, which strives to broaden student exposure within the advanced manufacturing sector. In addition to taking specialized courses, these students participate in a full range of activities, including seminars and networking events with manufacturing leaders.

At the undergraduate level, the Institute for Multidisciplinary Design & Innovation (UT-IMDI) offers engineering students an unparalleled experiential learning opportunity with industry. Companies such as Bombardier Aerospace, Pratt & Whitney Canada, UTC Aerospace Systems and Magna Advanced Technologies work with UT-IMDI to design capstone projects for multidisciplinary teams of fourth-year engineering students to solve. Companies benefit from innovative and cost-saving ideas to implement in their own operations, not to mention leads on highly trained engineers who are ideally suited to work for them.

For undergraduate students interested in furthering their knowledge in advanced manufacturing, TIAM is developing a new academic minor, slated to launch in 2016. Students enrolled in this minor will take a combination of courses that focus on the fundamental pillars of manufacturing, including manufacturing engineering, materials, process engineering and electronic devices. Upon completion, students will be poised to enter a career or graduate program focused on advanced manufacturing, such as the MEng program.

OUR MULTIDISCIPLINARY EXPERTISE

U of T Engineering has a rich history in the area of advanced manufacturing that spans a variety of disciplines. Together, we create next-generation materials, components and processes that drive tomorrow's economy. Here are a few of our leading experts.

CHRIS BECK

INTELLIGENT DECISION ENGINEERING

One size no longer fits all. Manufacturers are increasingly moving from large batches of identical products to a more tailored approach, with smaller batches and more variability between production runs. The use of computer-controlled, reconfigurable machines to quickly switch between different products requires agile decision making about production and supply-chain operations. To make the right choices, manufacturers need leading-edge information and reasoning technology.

Professor Chris Beck and his team at the Toronto Intelligent Decision Engineering Laboratory specialize in optimization and reasoning techniques. Drawing from the fields of operations research and artificial intelligence, these techniques have a track record of success in developing schedules for sectors such as health care, energy and manufacturing. By turning raw numbers into smart decisions, their algorithms can make the best use of available resources, lower costs and improve efficiency.

KERYN LIAN

ELECTROCHEMICAL CAPACITORS

Whether you're building a smartphone or an electric car, the demand for longer battery life seems insatiable. But batteries aren't the only way to deliver power, and Professor Keryn Lian's team is at the leading edge of a complementary technology: electrochemical capacitors.

Electrochemical capacitors can discharge at a rate much higher than traditional batteries, making them ideal for providing a boost of power when needed, such as when an electric vehicle drives uphill. Lian and her team are developing new materials and architectures that can improve the performance of capacitors while keeping weight and costs low. For example, flexible capacitors could fit into almost any space, whether it's the body of a vehicle, the casing of a mobile phone or the underside of a solar panel. These abilities allow more freedom in design and can help manufacturers meet specifications in unconventional ways.

JAVAD MOSTAGHIMI

ADVANCED COATING TECHNOLOGIES

What do non-stick cookware, space shuttles and artificial hips have in common? They all rely on coatings, whether to protect against heat damage, reduce friction, become more biocompatible or simply resist wear and tear.

The Centre for Advanced Coating Technologies (CACT), co-founded and directed by Professor Javad Mostaghimi, contains a battery of machines for applying coatings in almost any way imaginable. Here, researchers use detailed computer models and lab tests to ensure that each drop of coating is deposited with precision.

This allows companies to maintain quality while increasing efficiency and reducing cost.

GOLDIE NEJAT

ROBOTICS AND AUTOMATION

Professor Goldie Nejat, Canada Research Chair in Robots for Society, heads the Institute for Robotics & Mechatronics (IRM), which brings together nearly 40 experts in mechanical, electrical and aerospace engineering, along with leading researchers in computer science. IRM research includes the development of new actuator, control and sensory technology for cars, surgical devices and advanced manufacturing machinery.

IRM's multidisciplinary collaborations with Canadian industries focus on creating state-of-the-art sensors, integrating them with existing robotics and designing the algorithms that turn data into reliable and adaptive decision-making. These next-generation intelligent robots will enable companies to effectively automate and learn more about their process than ever before, developing high-quality products and identifying and fixing problems before they reach consumers.

CHUL B. PARK

MICROCELLULAR PLASTICS

Professor Chul B. Park and his team at the Centre for Industrial Application of Microcellular Plastics (CIAMP) are world leaders in developing innovative, cost-effective technologies for foamed plastics. Applications of their work run the gamut from heat and sound insulation to electrical insulators and household electronic devices.

CIAMP contains unique equipment that allows industrial partners to test new ways of making components out of foamed materials, from packaging to electrical insulators to impact panels. CIAMP is integrated into a nation-wide network of experts that can provide insight at every stage of the production process: initial design and testing, pilot scale analysis and full industrial production.

CRAIG STEEVES

ENHANCED AVIATION MATERIALS

When most people board a plane, they aren't thinking about the complex, invisible structures that make up the body or wings of the aircraft. Thankfully, Professor Craig Steeves of U of T's Institute for Aerospace Studies is. Together with Professor Glenn Hibbard, Canada Research Chair in Cellular Hybrid Materials, they are using additive manufacturing capabilities to develop new materials for use in aviation that are lighter and stronger than anything seen before.

Manufacturing these strong, lightweight components is a two-step process: 1) 3D print a polymeric template which is then metalized; 2) deposit a coating of metal that has nano-scale grains, making it very strong. Combining complex geometry and high-performance material opens up a world of possibility for sustainable aviation, manufacturing and beyond.

Visit uoft.me/aviationmaterials to read the full article originally published in U of T's *Edge Magazine*.