RESEARCH IN FOCUS:

NANOENGINEERING

CHALLENGE:

How can we make smartphones smarter, solar energy less expensive and medical conditions easier to diagnose?

SOLUTION:

Leverage the power of nanoengineering.

UNIVERSITY OF TORONTO | Engineering

TINY SOLUTIONS FOR BIG PROBLEMS

At U of T, nanoengineering is thriving. Our unique facilities enable our partners in industry to build the 21st century nanotechnologies needed to provide faster, greener and more resilient products. Whether you are a sector-leading company looking for new innovations or a nimble startup aiming to bridge the gap between concept and commercialization, U of T Engineering has what you need to take your project to the next level. We have a strong track record of success, entrepreneurship, patents, inventions and industry solutions.

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

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THE POWER OF PARTNERSHIP

One nanometre is to the thickness of a human hair as one inch is to a mile. It is hard to imagine designing something so small, but U of T Engineering researchers can. Common devices — including the integrated circuit boards found in smartphones, cars, TVs and even kitchen appliances — contain layers of electrically conducting materials only a few nanometres thick.

Seeing a structure that is smaller than the wavelengths of visible light requires advanced techniques, which is why the Ontario Centre for the Characterization of Advanced Materials (OCCAM) is so critical. Made possible by a partnership with Hitachi Technologies Canada, which provided both funding and state-of-the-art equipment, this brand new, $33-million facility contains tools that can analyze materials and surfaces with world-leading precision. It is led by Professor Doug Perovic of the Department of Materials Science & Engineering and Professor Charles Mims of the Department of Chemical Engineering & Applied Chemistry.

One unique technology in development at OCCAM is a transfer system that allows the movement of samples from one piece of analysis equipment to another while maintaining an ultra-clean, high-vacuum environment. "It's essentially like a vacuum suitcase," says Perovic. "This isn't done anywhere else in the world."

Such facilities provide an understanding of how changing a material at the nano scale results in new properties, from increased strength to altered electrical conductivity. These new materials, in turn, could transform everything from consumer electronics to clean energy.

*"Most engineers design **with** materials; our business is design **of** materials."*

PROFESSOR DOUG PEROVIC
Celestica Chair in Materials for Microelectronics

THE DETAILS

With a world-leading facility for nanoengineering, Perovic's team has created an artificial leaf. It was built with an array of nanostructures with photocatalytic properties that absorb energy from sunlight and react with carbon dioxide in the air to create a liquid or gaseous fuel. The rate of production is still too low to be economically feasible, but OCCAM could help the team evaluate new catalysts to make the dream of manufactured photosynthesis a reality.

Professor Ted Sargent's team in electrical and computer engineering are perfecting the cutting-edge technology known as quantum dot solar cells. Quantum dots are semiconducting nanoparticles that can be tuned to absorb different wavelengths of light. Quantum dots have the potential to significantly reduce the cost of producing solar cells. Along with IBM Canada Research and colleagues from several other Ontario universities, Sargent's team is part of the Southern Ontario Smart Computing Platform that builds and tests hundreds of virtual materials before starting work on a real device.

Professor George Eleftheriades in electrical and computer engineering is pursuing materials that bend light in ways that almost sound like magic. Recently, his team created an 'invisibility cloak' that can mask an object from the type of light used in radar. Along with Professors Joyce Poon, Sorin Voinigescu and seven other colleagues, Eleftheriades is creating the Centre for Reconfigurable Electromagnetic Surfaces (CERES). By leveraging existing partnerships with companies like Huawei Canada, Altera, ITS Electronics, AUG Signals, Comdev, Blackberry and organizations like Defence Research Development Canada, CERES will focus on developing ultra-thin surfaces that can manipulate electromagnetic waves for a variety of applications, including medical diagnostics.

PROFESSOR GLENN HIBBARD
NANOARCHITECTURE FOR STRONGER MATERIALS

A bridge is mostly empty space; it is the unique shape of the trusses and struts that provide its strength. Professor Glenn Hibbard and his team are applying that same principle on the nano scale, designing intricate 3D structures that lead to lighter, stronger materials for use in the aerospace industry and more.

Hibbard's team builds their scaffolds using polymers (plastics) which are easy to manipulate but do not have much compressive strength. They then coat these scaffolds with tiny crystals of high-strength metals. The smaller the crystals, the more resistant they are to cracking and damage. Such materials are ideal for use in space (for example, in satellites, planetary rovers and other applications) where weight is a liability.

The same approach can be used to build materials from plant-derived biopolymers that are durable but also recyclable. Hibbard's spinoff company, FlyTechnologies, is dedicated to commercializing these new materials.

A microscopic view of a microtruss coated in a thin sleeve of nanocrystalline metal.

PROFESSOR WARREN CHAN
NANOTECHNOLOGY IN HEALTH CARE

Can nanotechnology improve human health? Professor Warren Chan, a biomedical engineer who holds the Canada Research Chair in Bionanotechnology, thinks so.

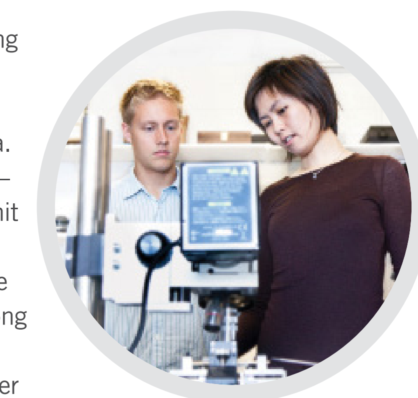
Cancer treatment is one promising application. Because tumour systems are 'leaky,' they can be infused with nanoparticles that make tumours easier to spot with medical imaging techniques. These nanoparticles, made of gold and other materials, can also provide a possible avenue for treatment: lasers can heat up the nanoparticles and destroy the cancer cells.

By using strands of DNA to link nanoparticles together — much like LEGO blocks — Chan and his team can control the properties of this new technology, including how easily they are taken up by cancer cells. They can also make nanoscale 'cages' that deliver drugs or other nanotechnologies to light up or kill tumours.

Like any substance introduced into the body, some types of nanoparticles can have negative health effects at high doses, but Chan cautions against painting all nanoparticles with the same brush. His team is adding to medical research by measuring how the size and composition of nanoparticles affect their journey through the body. They also developed non-invasive techniques to measure nanoparticle exposure. All of these developments will lead to safer nanotechnologies that can diagnose and treat many diseases.

PROFESSOR JOYCE POON
LIGHTING UP THE CLOUD

The rise of cloud computing requires the rapid transmission of ever-increasing volumes of data. Optical communications — which use lasers to transmit data at the speed of light over optical fibers — is the technology of choice for long distances, but most local networks still rely on copper wire, which is cheaper but slower.



Professor Joyce Poon and her team are addressing this challenge by creating smaller, less expensive devices and circuits for short optical communication links that can replace the copper wires. The team researches on integrated photonic devices and circuits implemented in silicon, compound semiconductors, and phase transition materials that change between insulating and conducting states. They spend a lot of time studying and understanding physical effects before they use them to create new devices. This often enables them to overturn long established ideas. The photonic integrated devices and circuits can one day be used in large data centres or 'server farms' that power cloud computing and social media systems.

Pictured above: Professor Joyce Poon — Canada Research Chair in Integrated Photonics — works with a graduate student in the Micro/NanoPhotonics Laboratory.