CMC MICROSYSTEMS

# IMPACT

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## Highlights

This issue of IMPACT illustrates how Canadian researchers, working together with CMC Microsystems, are among world leaders in this new microsystems era—an era where the combination of enabling technologies promises to create a socio-economic engine for our nation.

The ability to bring together or mix technologies is known as 'microsystems integration' and provides the basis for many new and innovative applications. Significant gains are often made in the cost reductions or performance enhancements of the technology that is embedded inside the products of today and tomorrow. Opportunities are emerging across the country.

Dr. Muthukumaran Packirisamy of Concordia University is combining technologies to create an integrated system with the potential to improve human health and security. At the Royal Military College of Canada, Dr. Aboelmagd Noureldin is working with private sector partners to develop small, low-cost automotive systems that will provide robust and reliable information to help drivers navigate big cities. And at the University of Alberta, Dr. Walied Moussa is combining technologies to develop applications that will enable productivity gains in the energy industry.

Integrated microsystems also promise to improve health care delivery for Canadians. For example, Jeffrey Keilman, former graduate student at the University of Calgary, collaborated with a Bio-Research Group to develop a standardized hardware platform that can create varying electric fields to perform specific types of cell manipulation.
Dr. Ridha Ben Mrad at University of Toronto is combining microsystems technologies to accelerate the analysis and delivery of diagnostic results for patients. At École Polytechnique de Montréal, Dr. Romain Maciejko is developing a rapid, non-invasive and cost-effective imaging technology that promises to improve detection of a wide variety of diseases, including cancer and heart disease.

CMC Microsystems is proud to support the researchers who are leading this microsystems revolution. Whether the impact is realized within the health care system, the oil sands of Alberta, or in the family vehicle, this new era promises to deliver many economic and social benefits for generations of Canadians to come.

Sonya Shorey, Editor

**Dr. Muthukumaran Packirisamy, Assistant Professor, Department of Mechanical and Industrial Engineering, Concordia University, is creating microsystems that will enable more effective DNA sampling and analysis techniques; and will ultimately improve disease detection, diagnosis, treatment and prevention.**

# 'Biological Transport System' Charts New Opportunities to Improve Human Health and Security

Increasing health and security challenges of the 21st century demand new solutions—solutions that rely on new expertise, innovative approaches and combinations of technologies. Researchers at Concordia University are responding by creating microsystems that will enable more effective DNA sampling and analysis techniques; and will ultimately improve disease detection, diagnosis, treatment and prevention.

The ability to combine different technologies offers tremendous potential to improve human health and security. Just ask Dr. Muthukumaran Packirisamy, an Assistant Professor at Concordia University who is benefiting from the technical expertise, tools and technologies provided by CMC to develop a novel 'biological transport system' for DNA sampling and analysis, chemical sensing and other related applications. The team is combining optical, biological, mechanical and electronic technologies, to create an 'integrated system' that is considered to be the first of its kind in the world.

### In This Issue:



Spring 2006

## What is microsystems integration?

**Microsystems integration is the mixing or combining of different technologies, like the concept of combining individual blocks of Lego to build a structure. It provides the basis for many new and innovative applications. Significant gains are often made in the cost reductions or performance enhancements of the technology that is embedded inside the products of today and tomorrow.**

"Over the next two to three years, our goal is to add optical and biological elements to the existing mechanical and electronic ones. This system could then be used in devices for a variety of life science and security applications."

Dr. Muthukumaran Packirisamy
Assistant Professor
Department of Mechanical and Industrial Engineering
Concordia University

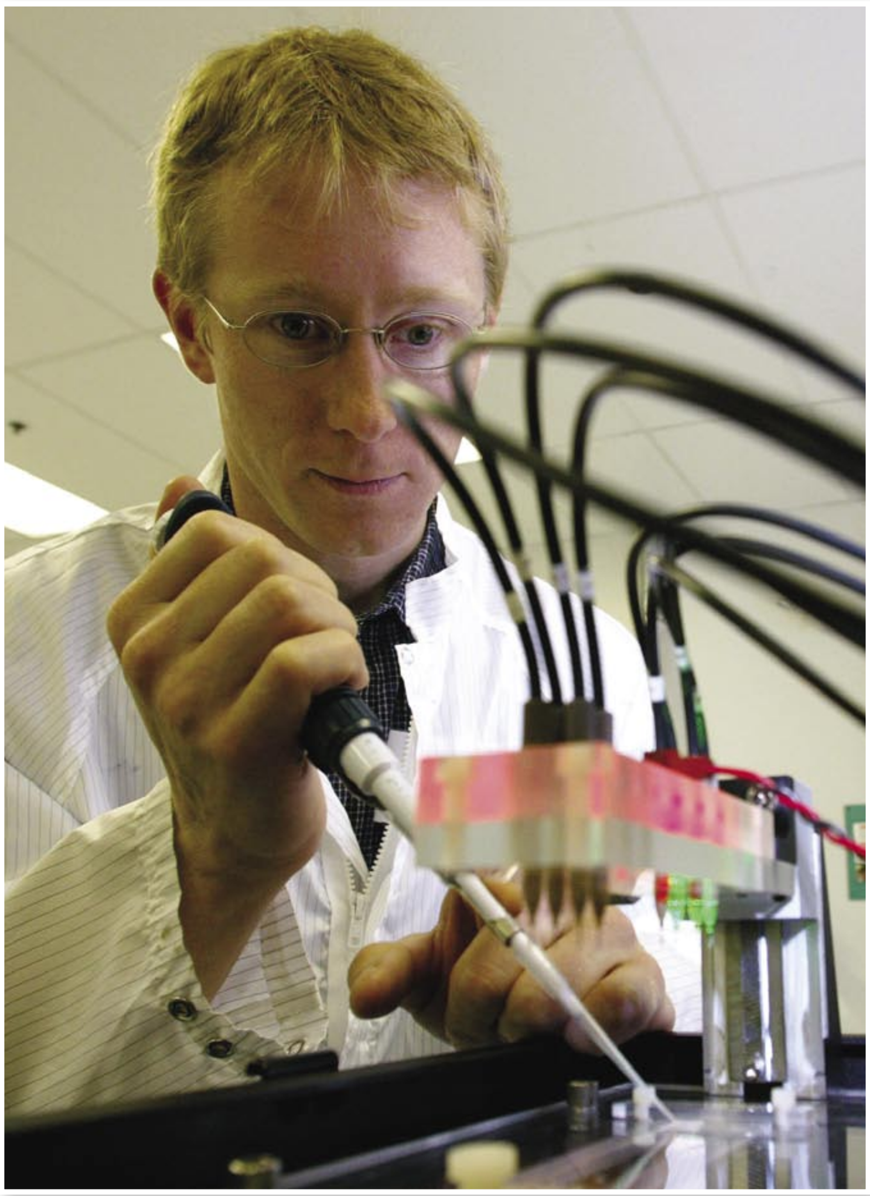
Dr. Packirisamy and his team started the project with two separate research bases or platforms: the first for microfluidic technology and the second for micromechanical and photonics technologies. They relied heavily on the specialized microfluidic products and services made available through a strategic partnership between CMC and Micralyne Inc. of Edmonton, Alberta.

Dr. Packirisamy has used the products and services provided by CMC for over 10 years. "CMC Microsystems has provided critical support to our research team in many ways—from enabling the development and layout of the design, to the manufacturing and packaging of the device, and the technical guidance required to address processing and integration challenges. They also supported our use of exploratory technologies and experimental facilities—this was critical to the success of this research. We received outstanding support from the employees of CMC on all aspects of the project."

He applauds the microsystems research capability delivered by CMC through strong alliances with industry leaders such as Micralyne. It has given him the confidence to move forward with the development of a fully integrated biophotonics microsystem. He currently holds a patent related to the project and anticipates commercializing the technology within the next five years.

"Access to microfluidic technology has provided a wealth of new opportunities for research, discovery and application."

It is researchers such as Dr. Packirisamy who are keeping Canada at the forefront of the global race to commercialize a new generation of integrated microsystems. *cmc*



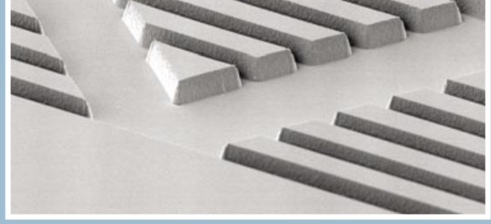
**John Crabtree, Director of Research and Development for Micralyne Inc., injects a liquid onto a microfluidic chip. CMC has partnered with the Edmonton-based company to enable improved access to microfluidic technology for researchers across Canada.**

## What are microfluidic chips?

**Think of a microfluidic chip as a lab-on-a-chip that allows minute volumes of liquids or gases to be tested quickly and easily. These miniature labs can perform tasks such as separating blood cells and analyzing DNA. Microfluidics technology enables:**

**Faster Diagnostics: In the future, patients could have a tissue sample taken in a doctor's office to find out immediately if they have a particular illness or disease. This will lead to faster diagnoses and more effective treatments.**

**Drug Discovery: Microfluidics makes emerging small volume fluidic techniques used in the analysis of hundreds of thousands of compounds more effective, enabling the rapid and relatively inexpensive identification of new pharmaceuticals.**



# CMC Microsystems at Work in Alberta's Oil Sands

**Dr. Edmond Lou, Adjunct Professor, Department of Electrical Engineering (left), and Dr. Walied Moussa, Associate Professor, Department of Mechanical Engineering (right), at the University of Alberta, are developing a new wireless sensor—with '*CMC inside*'—that is designed to monitor the structural health of mining equipment at the Fort McMurray oil sands in northern Alberta.**

Syncrude Research Centre is interested in testing a new wireless sensor—with '*CMC inside*'—that is designed to monitor the structural health of mining equipment at the Fort McMurray oil sands in northern Alberta.

"We are aiming to develop technology that is rugged and reliable enough for harsh environments such as the oil sands of Northern Alberta. Our research team is moving beyond laboratory-style equipment that is too delicate for these conditions, to a robust MEMS device that performs well in these environments. Microsystems technology promises to revolutionize energy production, making it more efficient and cost-effective for Canadians."

Dr. Walied Moussa
Associate Professor
Department of Mechanical Engineering
University of Alberta

Dr. Walied Moussa's goal is to transform how mechanical and civil engineers monitor the mechanical strain in mining equipment, airplanes, bridges and even biomedical implants. The researcher from the University of Alberta is exploiting microsystems technology to combine and integrate a strain gauge sensor, an antenna and a power source on a single system that could be mounted on the side of moving equipment or static structures.

Strain gauges are used to measure the stress on structural components. Unfortunately, these gauges currently rely on wires to transmit data—a requirement that is riddled with potential challenges for the operator. Dr. Moussa relied on access to software tools and design kits provided by CMC to develop the integrated MEMS-based sensor for potential application in the mining sector.

"With standard mining equipment such as a crusher, wires are often problematic and incur risk," explains Dr. Moussa. "If they are severed or damaged, the operator is required to re-wire or possibly replace some of the components on these gauges, often at a cost of $500 per unit. Wireless technology offers a more cost-effective and efficient solution for these environments."

Syncrude Canada Ltd. of Fort McMurray, Alberta demonstrated immediate interest in this new technology and is contributing to the project as an industrial partner. Plans are evolving to test an early prototype to explore its functionality and performance in the western terrain of the oil sands.

Dr. Moussa's innovation also offers the ability to conserve battery life by transmitting data only when structural changes occur. This helps to extend the battery life of the device by one to two months, facilitating an additional cost-savings for the mining companies and those in other industrial sectors.

His team is using design tools provided by CMC to overcome another major limitation encountered with strain gauges: the material properties used to assess the strain in a structure vary with temperature. In Spring 2006, his research team aims to finalize a new sensor design that enables effective calibration, regardless of the effect of thermal change on the strain gauge.

Over the coming year, Dr. Moussa will work with CMC to integrate the sensor, the wireless capability and the power source onto a single chip. His goal is to create a MEMS strain sensor that will help reduce the operating and maintenance costs incurred by companies such as Syncrude. As articulated by Dr. Moussa, the research will also have a significant impact on the development, commercialization and utilization of wireless MEMS sensors in the mechanical, biomedical, civil and aerospace industries: "When we realize this goal, it will be a significant breakthrough for this technology." *cmc*

## What is a sensor?

**A sensor is a device or a component that can detect changes in its surroundings. For example, a light sensor can detect changes in brightness; a heat sensor can detect changes in temperature. Sensors are often connected to computers to capture data about a particular environment or situation.**

**Source: The Nutfield Foundation, Primary Design and Technology online glossary, www.primarydandt.org/home/index.asp**

## What are microelectromechanical systems (MEMS)?

**Microelectromechanical systems (MEMS) are small devices that usually contain moving parts, manufactured with dimensions of less than one millimetre (1000 microns), and with parts as small as 1 micron. For comparison, a human hair is 100 microns thick and a bacterium is 1-2 microns long.**

**Common MEMS applications include medical sensors, airbags in automobiles, aerospace navigation systems, and even ink jet printers.**

# Photonics Innovation—Imaging Technology for Medical Analysis

**Dr. Romain Maciejko, Professor, Department of Engineering Physics at École Polytechnique de Montréal is developing a rapid, non-invasive and cost-effective imaging technology that promises to improve detection of a wide variety of diseases, including cancer and heart disease.**

> "The new photonics services offered by CMC are extremely valuable for researchers. We are often very limited by what we can do within a university. Manufacturing original prototypes directly through industrial fabrication facilities is very expensive and you often have to alter your devices to match their processes. CMC's partnership with the Canadian Photonics Fabrication Centre provides researchers with access to state-of-the-art photonics fabrication. A working device increases the opportunity to commercialize research in the future."
>
> Dr. Romain Maciejko
> Professor
> Department of Engineering Physics
> École Polytechnique de Montréal

CMC Microsystems is making it possible for Professor Romain Maciejko of École Polytechnique de Montréal to develop a new type of high-performance and high-resolution optical imaging system that out-performs X-rays and ultrasounds in specific applications.

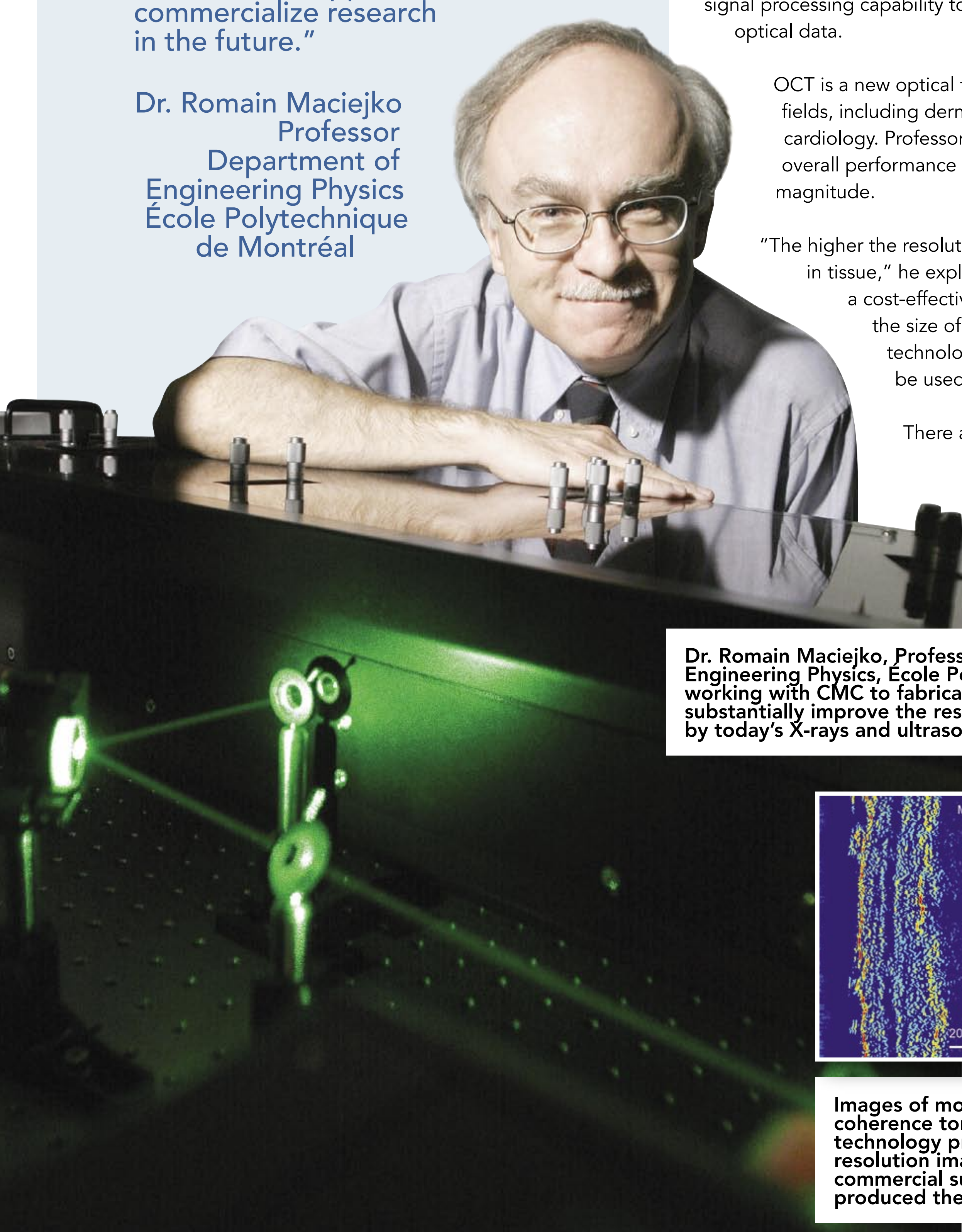
Dr. Maciejko is taking advantage of new photonics products and services offered by CMC Microsystems. A partnership between CMC and the National Research Council's Canadian Photonics Fabrication Centre (CPFC) enables university researchers to access the industry-grade photonics fabrication services offered by this facility.

The Ottawa-based CPFC is currently finalizing the prototype developed by Professor Maciejko for a broadband optical source that will help optical coherence tomography (OCT) produce high-resolution, real-time, three-dimensional images of biological tissue. Over the next few years, he will aim to develop a working prototype that combines the broadband light source with signal processing capability to enable the extraction of 3D images from the optical data.

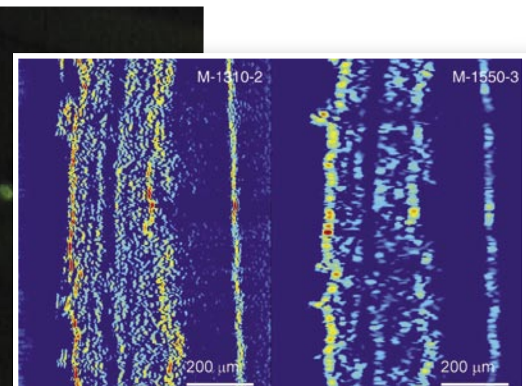
OCT is a new optical technology used in a growing number of medical fields, including dermatology, dentistry, gynecology, oncology and cardiology. Professor Maciejko is seeking to increase the resolution and overall performance of these imaging devices by at least one order of magnitude.

"The higher the resolution, the greater the opportunity to detect disease in tissue," he explains. "The research challenge has been to develop a cost-effective way to increase the resolution, while reducing the size of the components. We are aiming to package this technology into the size of a small suitcase, allowing it to be used easily in a hospital setting."

There are many potential applications for this technology, including the early detection of heart disease. Dr. Maciejko is working in collaboration with the Montreal Heart Institute and the National Research Council's Industrial Materials Institute on the project. *cmc*



**Dr. Romain Maciejko, Professor, Department of Engineering Physics, École Polytechnique de Montréal, is working with CMC to fabricate a compact device that will substantially improve the resolution of images produced by today's X-rays and ultrasounds.**




**Images of mouse tissue: optical coherence tomography (OCT) technology produced the high resolution image on the left, while a commercial supraluminescent diode produced the image on the right.**

# Manipulating Cells—Improving the Detection of Cancer and Other Diseases

**Jeffrey Keilman, a former graduate student at the University of Calgary, won the Micralyne Microsystems Design Award at the TEXPO Research Competition, during CMC's 2004 Annual Symposium in Ottawa. His award-winning presentation was entitled: *A Dielectrophoretic Bio-Analysis Platform Using Lexel Arrays*.**

Jeffrey Keilman, a former graduate student at the University of Calgary, won the 2004 Micralyne Microsystems Design Award in MEMS and microfluidics for research that could make it easier to detect cancer and other diseases.

"CMC Microsystems was invaluable in helping me to design this bio-analysis platform and verify that it works. It has also given me an opportunity to collaborate with my colleagues in biological sciences. It has certainly raised my awareness of how microelectronics and microfluidics can be used to improve our health care system in the future."

Jeffrey Keilman
Student
Faculty of Medicine
McGill University

The manipulation of biological particles is essential to our ability to understand cells and develop future treatments for common diseases. Jeffrey Keilman collaborated with the Bio-research Group at the University of Calgary to develop a standardized hardware platform that, with a simple software change, can create varying electric fields to perform specific types of cell manipulation. This includes isolating and trapping bio-particles for indepth analysis.

"The idea is to program multiple fields to perform multiple types of manipulation," explains Mr. Keilman, a former Master's student whose research was supervised by Dr. Karan Kaler and Dr. Graham Jullien, Professors at the University of Calgary. "The goal of my research was to create a more generalized electric structure, something that is automated and can be programmed and reconfigured for broad application."

Mr. Keilman, who is now studying medicine at McGill University, used design tools provided by CMC Microsystems to design a chip that produces these electric fields. The software control was implemented using field-programmable gate array (FPGA) technology, also provided through CMC.

The team aims to create a bio-analysis platform that rapidly and easily identifies, characterizes and manipulates biological particles. The process relies on a technique called dielectrophoresis, which uses the force from specific electric fields to levitate, separate and move particles. There are many potential applications for this technology.

For example, Dr. Karan Kaler, Professor, Electrical Engineering, at the University of Calgary and Dr. Linda Pilarski, Canada Research Chair in Biomedical Nanotechnology at the University of Alberta, are using dielectrophoretic techniques to develop better diagnostic tools for the detection of leukemia cells.

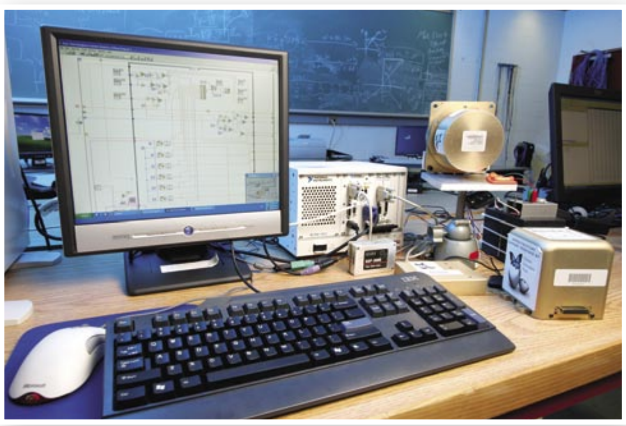
Mr. Keilman's research could contribute to the future development of a portable bio-analysis device that would help researchers and physicians quickly identify cells or bio-particles in the human body or the environment. *cmc*

## What is a Field Programmable Gate Array (FPGA)?

**An FPGA is a fabricated integrated circuit technology in which circuit behaviour is electrically configured (programmed into the integrated circuit) by the user to meet a specific design requirement. FPGAs are often used for prototyping because they can be reprogrammed for different applications, saving the considerable time and money involved in manufacturing chips.**

# Small Tech Helps Drivers Navigate Big Cities

**A researcher at the Royal Military College of Canada is working with CMC Microsystems to address the 'urban canyon effect'—when tall buildings or hills interfere with the Global Positioning System (GPS) used in automobiles.**



**Dr. Noureldin relies on tools and technologies provided through the System-on-Chip Research Network managed by CMC to advance his research and move his navigation technology closer to commercialization.**

"You can't rely on GPS all the time, especially in downtown cores. Our solution augments GPS with MEMS-based sensors and fuses both with artificial intelligence techniques."

Dr. Aboelmagd Noureldin
Assistant Professor
Department of Electrical and Computer Engineering
Royal Military College of Canada

Microelectromechanical system (MEMS) technology promises to help drivers where the Global Positioning System (GPS) cannot—in large cities. Dr. Aboelmagd Noureldin, Assistant Professor at the Royal Military College (RMC) of Canada in Kingston, Ontario, is working with CMC Microsystems to develop a small, low-cost navigation system that combines MEMS sensors and a GPS receiver chip onto a single board to provide drivers with continuous navigational information.

This new vehicular navigation and guidance system—the first of its kind to be developed in Canada—combines measurements from MEMS-based inertial sensors and GPS in real time to provide robust and reliable navigational information. A CMC-provided workstation with all the peripherals is essential to the project. The researcher will rely on access to the System-on-Chip Research Network managed by CMC to move the technology closer to commercial viability.

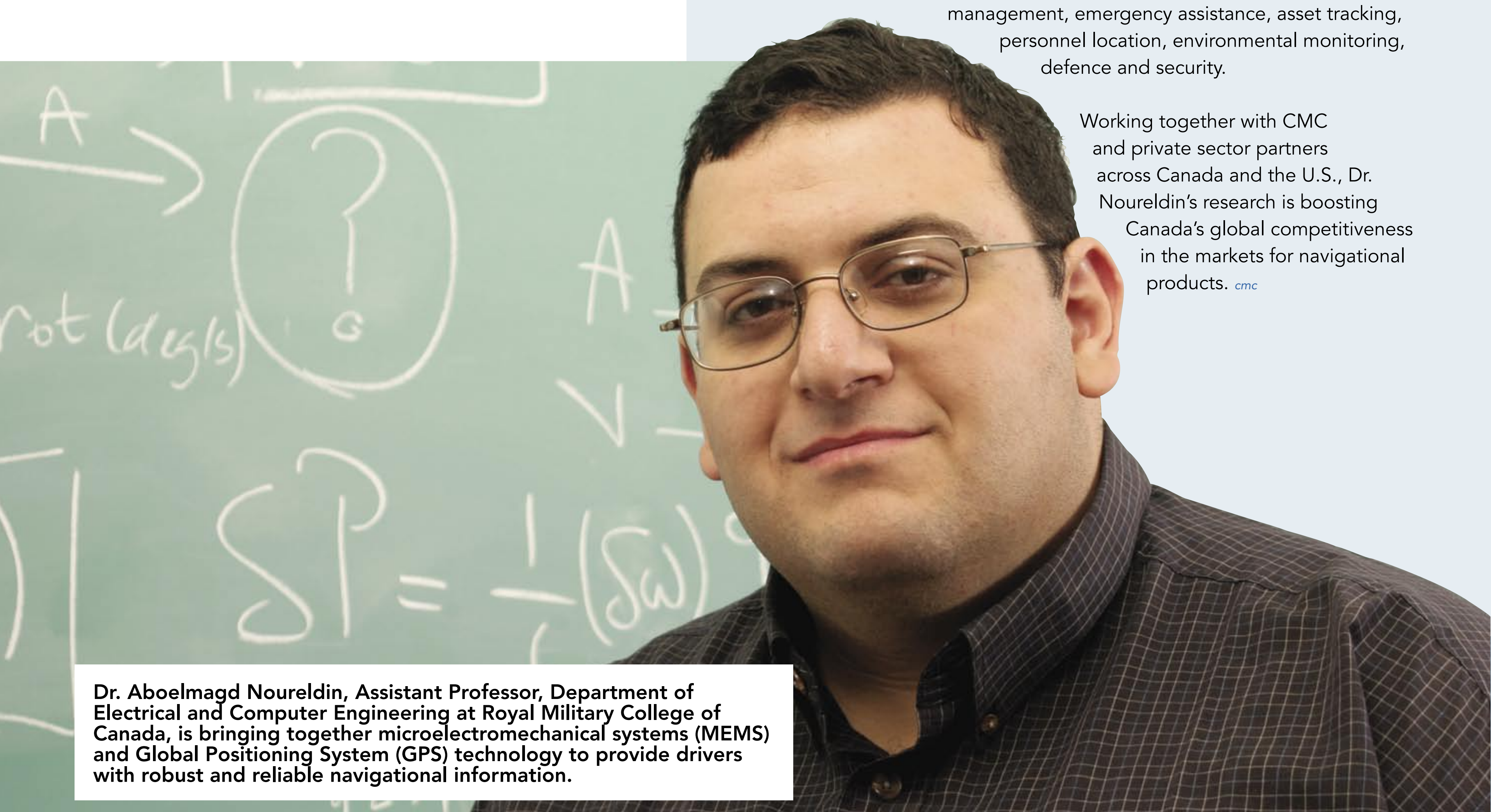
"CMC provides the workstation and the software for analyzing MEMS sensors, and brokers access to world-class manufacturing facilities. CMC also has expertise in MEMS and system-on-chip implementation—this knowledge is critical when trying to integrate different technologies," says Dr. Noureldin.

In March 2005, researchers at RMC successfully tested the ability of their software to integrate the functionality inside land vehicles. The results have already been published in several scientific papers. It was also the thesis topic of one of Dr. Noureldin's graduate students.

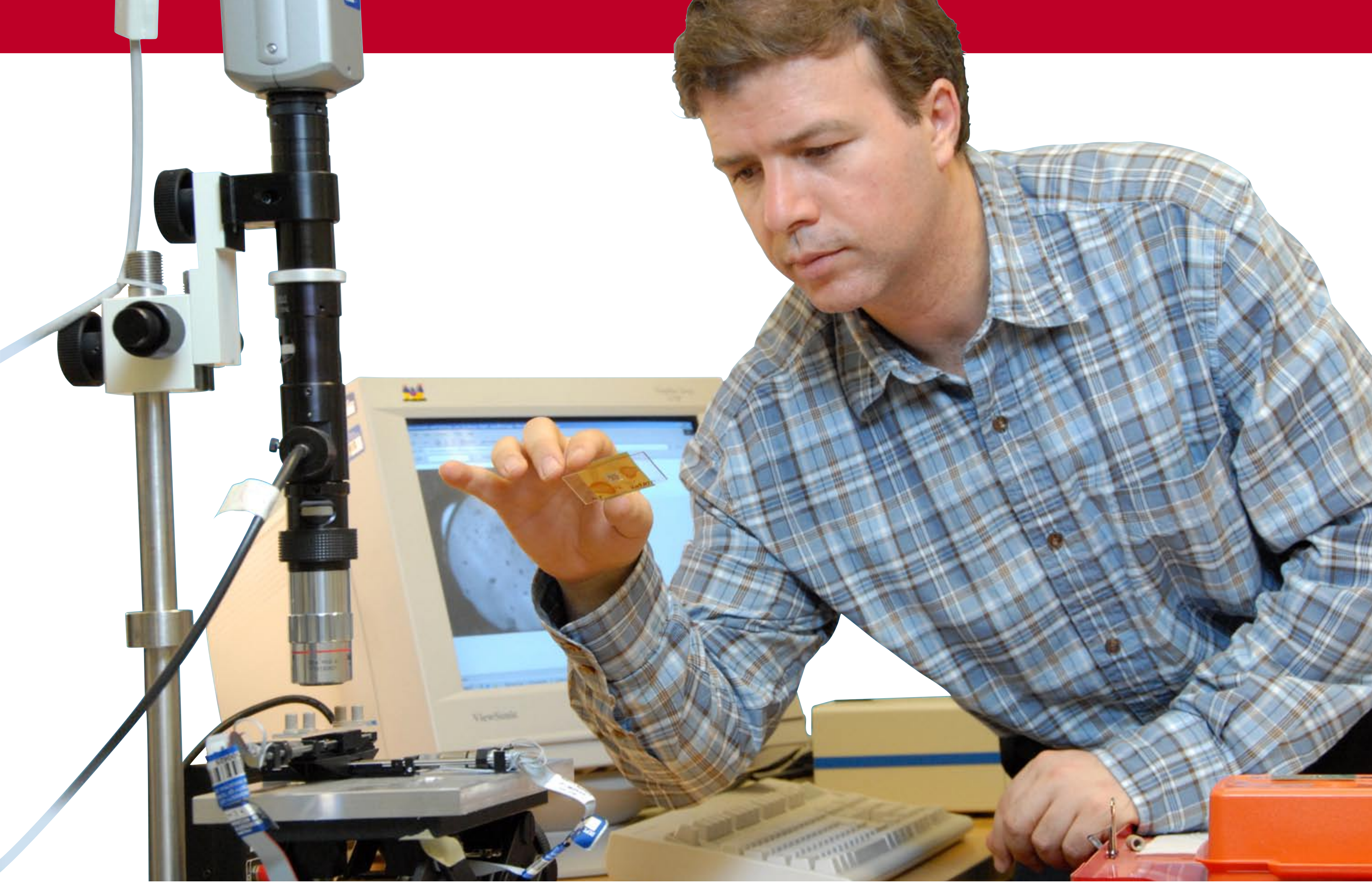
Dr. Noureldin is now focusing on the hardware. He plans to work with CMC to manufacture the MEMS sensors, which include accelerometers and gyroscopes. He hopes to complete a hardware prototype within the next two years.

Potential users of this technology include organizations involved in fleet management, emergency assistance, asset tracking, personnel location, environmental monitoring, defence and security.

Working together with CMC and private sector partners across Canada and the U.S., Dr. Noureldin's research is boosting Canada's global competitiveness in the markets for navigational products. *cmc*



**Dr. Aboelmagd Noureldin, Assistant Professor, Department of Electrical and Computer Engineering at Royal Military College of Canada, is bringing together microelectromechanical systems (MEMS) and Global Positioning System (GPS) technology to provide drivers with robust and reliable navigational information.**



**Dr. Ridha Ben Mrad, Associate Professor, Mechatronics and Microsystems Design Laboratory at the University of Toronto, is combining microsystems technologies for biomedical diagnostic devices that aim to accelerate the analysis and delivery of results.**

# Diagnostics that Deliver Faster Results for Canadians—at a Fraction of the Cost

Researchers at the University of Toronto are combining microsystems technologies to build a 'miniature plumbing system' for biomedical diagnostic devices that aims to accelerate the analysis and delivery of results—at a fraction of the cost of diagnostic tools available today.

"CMC has provided invaluable support to this project. This includes providing graduate students with feedback on their designs, facilitating fabrication through Micralyne and developing new packaging solutions to enable testing of the devices. CMC's proactive identification of new suppliers also enables researchers to access the specialized facilities required to explore new concepts and research possibilities."

Dr. Ridha Ben Mrad
Associate Professor
Mechatronics and Microsystems Design Laboratory
University of Toronto

Microfluidic technology promises to revolutionize the detection and diagnosis of disease, improve the monitoring of food and water quality, and preserve our environment—provided we get the plumbing right.

Dr. Ridha Ben Mrad and his team at the University of Toronto are working with CMC Microsystems to realize this promise.

Leveraging a suite of microfluidic tools and fabrication services, as well as years of technical expertise provided by CMC, Dr. Ben Mrad is developing the miniaturized pumps, dispensers, mixers and valves required to move, separate and combine minute amounts of biological fluids on a single microchip.

This 'lab-on-a-chip' complements DNA microarrays that enable scientists to scan tens of thousands of genes simultaneously for analysis. It dispenses fluids with far greater accuracy than current commercial systems, while using fewer reagents (the substances used to bring about chemical reactions). This has enabled researchers to reduce the overall cost of the diagnostic device, while improving the quality and turnaround time for results.

"Eventually, these systems will also become highly efficient and cost-effective alternatives to the microarraying systems used today," he says. Once the team has completed the testing and verification of their first prototype device, using services provided through CMC, they will collaborate with Engineering Services Inc. of Toronto, Ontario to combine all of the microsystems components required to create an integrated device for commercial application. *cmc*

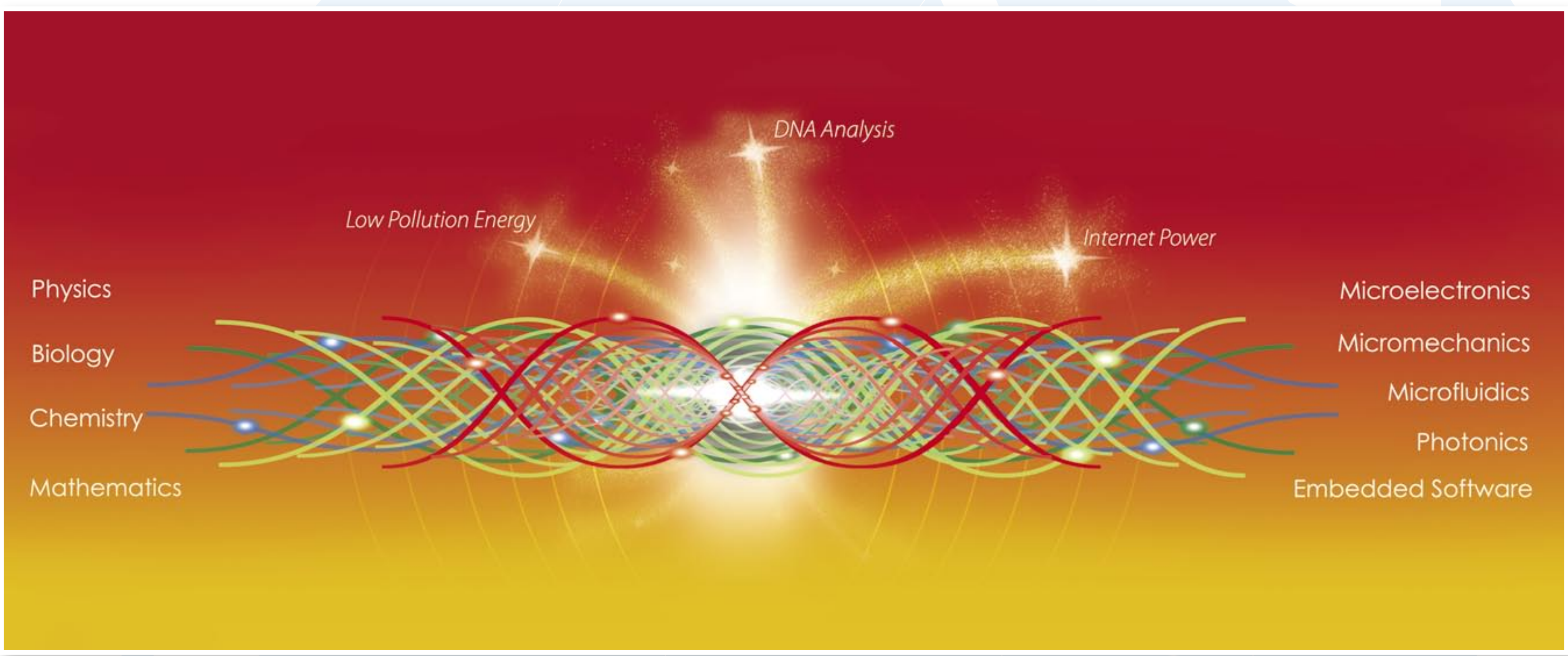
## What is a DNA microarray?

**A DNA microarray is a thumbnail-sized chip of glass or silicon that carries DNA instead of electronic circuits. DNA microarrays can identify the genes that are active within a cell and help identify mutated genes.**
**Source: MSN Encarta, encarta.msn.com**

# The Power of Microsystems

## What are microsystems?

- Small, versatile and powerful devices designed and built by scientists and engineers
- Amazing devices that sense their environment; make decisions using their built-in, miniature electronic brain; and then take action to help us in our daily lives
- All around us—in cell phones, air bags, security systems in airports, pacemakers, and water quality systems
- Engines for a 21st century economy, improving productivity, competitiveness and economic growth
- Enabling technologies for diverse sectors of the Canadian economy




**The fusion of microsystems technologies with knowledge from many disciplines generates innovations in diverse economic sectors.**

CMC Microsystems recognizes the outstanding contribution of its investors. Established in 1984, CMC is a not-for-profit corporation funded by Science and Engineering Research Canada (NSERC), matched by industrial contributions of technology, services and cash. CMC also manages major grants from the Canada Foundation for Innovation (CFI) and the Ontario Innovation Trust (OIT) through Queen's University, to deliver research infrastructure for system-on-chip investigations at Canadian universities; and, along with additional funds from the province of Québec and the Manitoba Research and Innovations Fund, to enable the testing of high-performance microchip designs through the National Microelectronics and Photonics Testing Collaboratory.

NSERC CRSNG
*Investing in people, discovery and innovation*
*Investir dans les gens, la découverte et l'innovation*

Canada Foundation for Innovation
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Ontario Innovation Trust

Québec

Manitoba Energy, Science and Technology

CMC MICROSYSTEMS

CMC Microsystems builds partnerships among government, industry and universities to enable and accelerate Canada's global competitiveness in microsystems. As Canada's leader in the provision of nationally-distributed infrastructure for microsystems research and technology development, CMC provides leading-edge tools and technologies for world-class research leading to innovation and commercialization of microsystems.

We want to hear from you! CMC Microsystems looks forward to any ideas or feedback you may have on *CMC IMPACT* or other communications initiatives. For more information, please contact: Sonya Shorey, Senior Manager of Communications, at 613.530.4698 or shorey@cmc.ca.

Design: SmallWorld Media Group