Designs in Fabrication

Canada's National Design Network®

Prototyping Report:

April 2021 – March 2022

CMC Microsystems

Lowering barriers to technology adoption

CMC Microsystems is a not-for-profit organization accelerating research and innovation in Canada. Founded in 1984, CMC lowers barriers to technology adoption by creating and sharing platform technologies, including access to state-of-the-art design, manufacturing, and testing capabilities for advanced technologies. CMC manages Canada's National Design Network® (CNDN) – a Major Science Initiative involving over 10,000 academic participants and 1,000 companies developing innovations in micro-nano technologies.

CMC Microsystems' fabrication reports describe Canada's National Design Network (CNDN) designs that have progressed to fabrication are published for distribution at:

www.CMC.ca/FAB

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FAB

CMC Delivers Over 400 Semiconductor Prototypes in Past Year

In an increasingly competitive market, CMC delivers its best performance in over a decade

May 3, 2022:

CMC Microsystems, Canada's leading accelerator for hardware research, design, and development, is proud to announce in the last fiscal year, CMC delivered chips and wafers for over 400 designs through our global network of semiconductor and photonics manufacturing facilities.

It's been a turbulent year in the semiconductor industry with supply chains and manufacturing capacity stretched to the limit, and lingering uncertainty in the wake of the global pandemic. Despite these challenges, research and development by academics and entrepreneurs benefiting from CMC's design tool and chip manufacturing program have been more active than ever in the past decade. Highlights from the past year include:

- Almost 160 photonic designs – double from the previous year
- Over 140 microelectronics designs manufactured in advanced semiconductor technologies
- Over 80 designs fabricated or post-processed in laboratories
- Over 40 micro-electromechanical systems (MEMS) and microfluidics designs
- Fabrication of 7 superconducting designs – a world first via a multi-project wafer service
- 80 designs manufactured for industry, industrial collaborators, or academics outside Canada

"Giving researchers and firms simplified access to the world's best fabrication services is part of CMC's core mission" said Gordon Harling, President and CEO of CMC. "We are proud to deliver this level of value for Canadian and international innovators, enable productivity, and help industries like photonics and quantum grow. These are specialty areas of the market set for huge growth where Canadian expertise is recognized internationally."

www.CMC.ca/cmc-NEWS

Looking for Collaborative Opportunities?

For further information we encourage you to contact researchers directly, or contact us:

FAB@cmc.ca

Introduction

CMC Microsystems (CMC) delivers key services including industrial-scale multi-project wafer (MPW) manufacturing services, value-added packaging and assembly services and in-house expertise for first-time-right prototypes. This report provides a view into the activities of researchers in Canadian post-secondary institutions by describing academic designs that have progressed to fabrication (FAB) between April 2021 and March 2022.

A World-wide Industrial Supply Chain

CMC's strategies focus on a supply chain ecosystem of more than 100 organizations – over 50 operating in Canada – that enables world-class industry/academic collaboration and expands support for industrial R&D. For example:

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2021/22 Highlights: Over 400 designs fabricated

- **327** designs fabricated through CMC's global network of (MPW) services.
- **81 designs** developed through Canada's MNT (micro- nano technologies) network of 40 university-based labs.

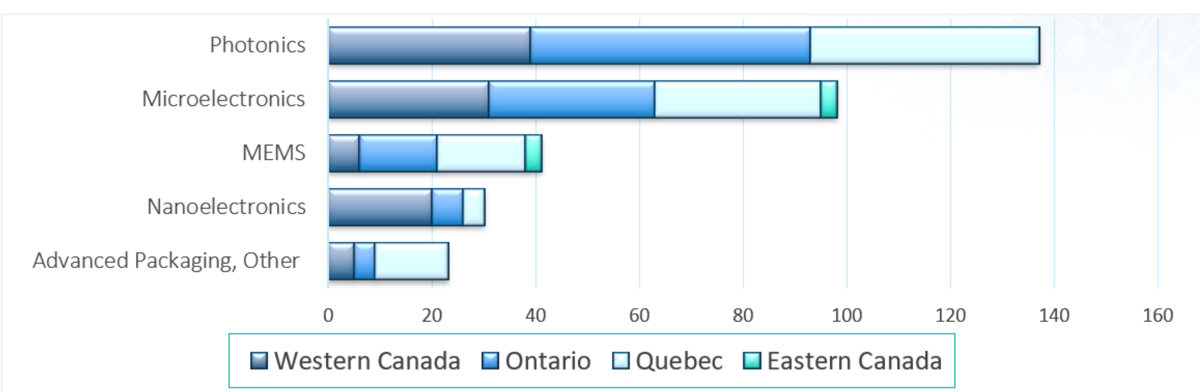
Designs in 2021/22: 408

329 by academics in Canada

66 by academics not-in-Canada

13 by industry in Canada

5 by industry not-in-Canada



Other includes special requests, microfluidics, & quantum designs (7).

Figure 1 – Academics in Canada: 330 (of 400) Designs Fabricated 2021/22

Five-year highlights: 1,600 designs fabricated

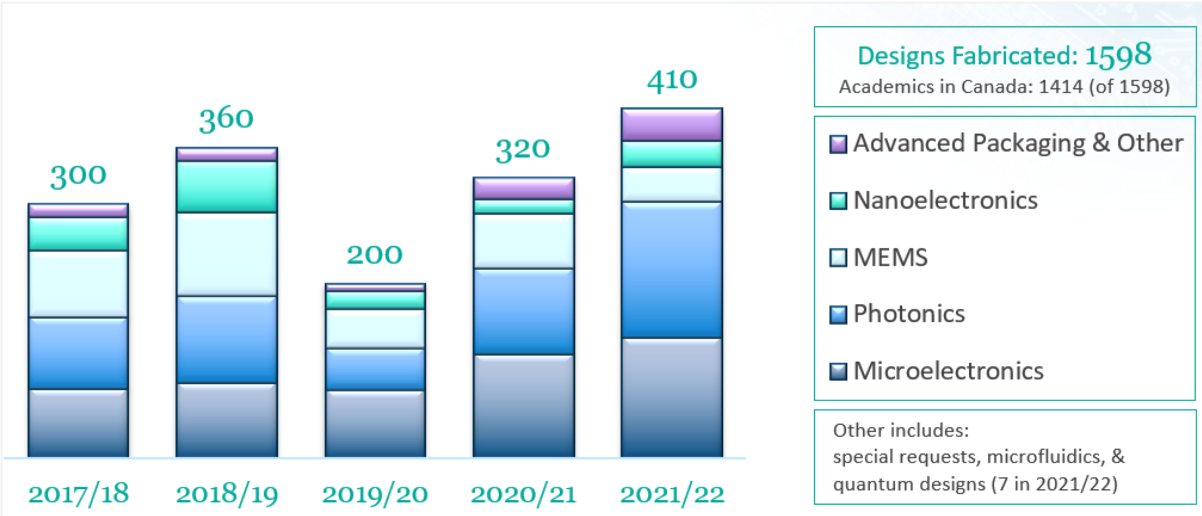


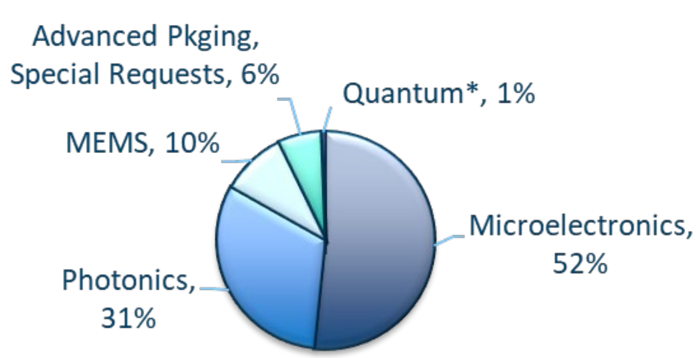
Figure 2 - Designs Fabricated 2016/17 - 2020/21

1,100 Photonics Designs Fabricated (as of March 2022)

- **800** silicon photonics designs (includes fabrication training program projects)
- **120** III-V photonics technology designs

R&D Programs

- **CMC SponsorChip™** is an opportunity for companies to accelerate their R&D, access tech talent, and support research in Canada. Visit: www.CMC.ca/SponsorChip
- **VIE – Virtual Incubator Environment** program offers start-ups access to software tools, CMC's technical expertise, and state-of-the-art fabrication. Visit: www.CMC.ca/VIE
- **Commercial Products & Services**: fabrication, packaging and assembly, R&D services backed by CMC's technical expertise and global supply chain, training, workshops, and networking events. (See Figure 3) www.CMC.ca/Commercial-Services



* New in 2021/22
Actual designs: 184 (representing 12% of total designs fabricated in period)

Figure 3: Five-year Industrial & Academic Located Outside Canada Designs Fabricated (2017/18-2021/22)

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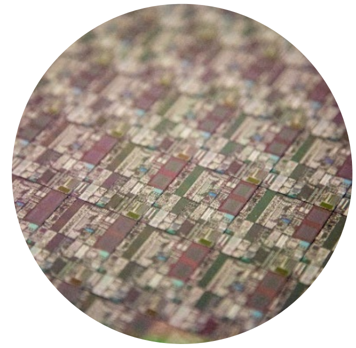
Microelectronics | www.linkedin.com/groups/14004388/

AI Systems | www.linkedin.com/groups/12323470/

IoT Platform | https://github.com/cmcmicrosystems

MICROELECTRONICS



Strategic partnerships ensure CMC has access to technologies across various foundries including AMS, GlobalFoundries®, STMicroelectronics, Taiwan Semiconductor Manufacturing Company (TSMC), and X-FAB. This portfolio supports researchers across a variety of growth areas, including Analog, RF, Mixed signal, RF, Digital and Optoelectronics.

Spotlight on microelectronics: www.CMC.ca/Microelectronics

Technology: 12-nanometer FinFET CMOS

GF 12LP

Detection and Compensation Techniques for Process Variation and Aging in FinFET Technology

Applications include: ICT (microelectronic reliability in high speed, low power telecommunications circuits)

We propose to build a set of sensing circuits based on ring oscillator topologies that allow us to detect threshold voltage (VTH) and drain current (ID) variation in devices of interest. Sensor readings will be verified by a complementary S-parameter test bench that focuses on the same set of devices under test. Additional parameters such as CISS, ID, gm, and transients will be measured. From sensor readings, adaptive circuits will correct bias conditions on an operating amplifier circuit to compensate performance for both PV and aging effects. The application is intended for both active compensation in live circuit operation as well as providing data for FinFET model advancement.

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Professor: Wai Tung Ng | ngwt@vrg.utoronto.ca

High-speed Low-power PAM4 VCSEL Driver and Transimpedance Amplifier (TIA)

Applications include: ICT

Due to the rapid increase in demands for higher data rate communication, short-reach optical interconnects have become more popular than before. The optical fiber is a promising candidate to handle high-speed large volume data, thanks to its wider bandwidth and less attenuation compared to its electrical counterpart such as copper.
In the optical receiver chain, the transimpedance amplifier (TIA) is the first block and typically limits the bandwidth, noise, and sensitivity of the whole receiver. Therefore, a TIA with a low input resistance is needed to increase the BW of the receiver. On the receiver side, we plan to implement a TIA with circuit novelties to enhance its BW with little adverse effect on the area, noise, and power consumption compared to the conventional techniques. The implemented receiver includes TIA, single-ended to differential block, variable gain amplifier, output buffer, photodiode dc current compensation mechanism, dc-offset cancellation mechanism, and automatic gain control loop. The required area for this design is 1 mm (horizontal) by 1.1 mm (vertical).

On the transmitter side, VCSEL is a low-cost and common laser that needs a driver for proper functionality. VCSEL typically shows a ringing behavior and overshoot/undershoot in its response. Thus, the driver needs some equalization techniques to relax this ringing behavior. In this research, we have proposed a new cascode voltage-mode driver which enhances the output swing voltage to 2VDD with less power and area overhead compared to the conventional methods. Also, a nonlinear analog-based feedforward equalization (FFE) technique is proposed to overcome both the static and dynamic nonlinearity of the VCSEL. The implemented transmitter includes input matching network, delay cell, level shifter, pre-driver, and driver. The required area for this design is 1 mm (horizontal) by 1.1 mm (vertical).

University Of Toronto
Designer: Milad Haghi Kashani | miladhk@ece.utoronto.ca
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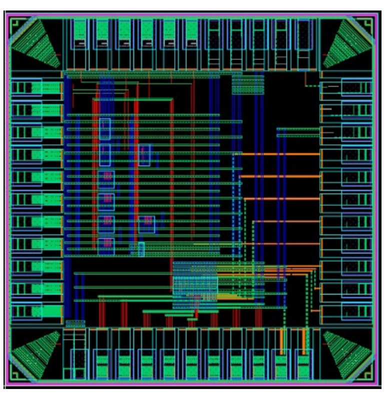
Novel Aging Measurement Circuitry Test Platform

Applications include: Aerospace, Automotive, Defence (Safety, Security)



With an abundance of mechanisms and varied stress conditions, device degradation has always been challenging to measure. This project design implements numerous novel circuits that attempt to isolate and directly measure degradation mechanisms such as NBTI, PBTI, n-HCI, p-HCI, EM, TDDB, and SILC. By isolating and quantifying these phenomena through multiple techniques, we plan to enable the development of modern comprehensive reliability characterization methodologies. Note that this design is concerned with the development of novel circuits that can measure and monitor device aging and is not interested in the specific reliability of the GF 12LP FinFET process.

University of British Columbia
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Sparse DNN Training Accelerator
Applications include: ICT

Machine Learning (ML) and DNN workloads have been ubiquitous in datacenters and mobile devices. Training of these workloads face severe challenges due to increasing model sizes and corresponding energy and latency costs. To enable training of DNN models with low latency and energy, we are fabricating a sparse DNN accelerator which leverages sparsity to skip computations to reduce runtime and energy by 3x, while maintaining the accuracy of the corresponding dense DNN models.

University of British Columbia
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Technology: 22-nanometer FDSOI CMOS

GF 22nm FDX

A Wideband Low Noise Amplifier Using the Transistor Backgate for Matching
Applications include: ICT

With the trend toward 5G wireless communication, high performance and mm-Wave low noise amplifiers (LNAs) are in high demand. The 22nm FDSOI process offers high-performance mm-Wave devices in terms of Ft, Fmax, and NFmin. This project aimed to implement a wideband LNA with an operating frequency range of 10GHz to 33GHz. The LNA is based on an inverter amplifier that uses the transistor backgate to have a wide input match and it uses gate-drain capacitance to achieve a wide noise match. The advantage of using this topology is the smaller area and lower noise figure in comparison to other mmWave bands LNAs. The simulation shows that the LNA achieves 1.74 dB minimum noise figure with 11.3 mW DC power consumption. The peak gain is 23dB at 22GHz.

University of Calgary
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Professor: Leonid Belostotski | lbelosto@ucalgary.ca

Analog Multitone Receiver
Applications include: ICT

This design is a wireline receiver capable of recovering data transmitted in two sub-bands, one centered at DC (baseband) and one centered at a high-frequency carrier (15 GHz). The Analog Front-End is composed of a bandpass filter, mixers, and baseband continuous-time linear equalizers; a multiple input – multiple output feed-forward equalizer; a slicer stage; clock generation and distribution circuitry; and an on-chip bit error rate tester (BERT).

University Of Toronto
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MMIC-1 and MMIC-2 2021

Applications include: ICT

1. ESD protection for high-speed, differential inputs. Human-body model protection (> 1.5kV) for circuits with DC to mm-wave frequency bandwidth.
2. mm-Wave-frequency resistive mixer with wide dynamic range.
3. Precision oscillator. Test circuits to benchmark building blocks for the precision oscillator prototype.
4. Output stage for a Mach-Zehnder modulator driver with 90-GHz bandwidth.

University of Waterloo
Designer: Bolun Cui | b3cui@uwaterloo.ca
Professor: John Long | jrlong@uwaterloo.ca

Software Defined Wireless TX

Applications include: ICT

A digital wireless transmitter (TX) suitable for multi-standard operation is implemented using a quantized analog signal processing. The scaling-friendly design does not require any active circuitry for digital to analog conversion and baseband filtering resulting in low power dissipation. Thanks to the high order reconfigurable filter, it reduces out-of-band emissions while improving the noise in the RX-band for FDD applications. The introduction of a QA signal processing stage obviates the need for backoff resulting in improved power efficiency. At the same time, it can accommodate larger baseband swings, multi-standard operation and leads to smaller baseband capacitance for the same SNR target.

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Study Aging Effects in 22nm FDSOI Technology Node

Applications include: Automotive

This project is to study the silicon aging in critical circuit structures of integrated circuits (ICs) caused by charge trapping and electromigration. Transistor aging effects are due to the charge trapped in the gate oxide or the interface stage. This is addressed under bias temperature instability (BTI) and hot carrier injection (HCI) stress. At the same time, electromigration could induce degradation of the conductors in ICs, causing intermittent glitches and eventual failure. In this project, we designed ring oscillators with different logic styles and developed a test vehicle that carry out efficient statistical aging measurements involving the charge trapping and electromigration. The test vehicle is used to study the aging mechanisms in critical circuit structures under various conditions and understand the accelerated failure mechanisms due to feedback in critical circuits. The simulation results showed that the testing system could detect the minimal BTI recovery in microseconds as well as fine frequency shift measurement resolution. This will bring insight understanding of aging mechanisms in 22nm FDSOI integrated circuits. This project is sponsored by Cisco Systems and collaborated with Professor Chris Kim at University of Minnesota.

University of Saskatchewan
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Professor: Li Chen | li.chen@usask.ca

Technology: 28-nanometer CMOS

ST 28nm CMOS FDSOI

A High Speed and Low Power Comparator for ADC Applications

Applications include: Aerospace

This project aims to implement a versatile Systems-on-Chip integrated sensor interface for Aircraft Applications. The submitted comparator design is a part of a high-speed and high-resolution ADC used in sensor interfaces. The overall structure of the proposed ADC in based on noise-shaping SAR (NS-SAR) ADC which uses the comparator design in the architecture of SAR ADC. The comparator is used to compare the voltages on the DAC for controlling the DAC switching process and producing the output bit stream of the ADC. In NS-SAR ADCs, comparator noise and offset are shaped but the speed and power consumption are still important design parameters. This structure can provide low offset and fast performance because of using the cross-coupled preamplifier and StrongARM latch in its structure. Also, using low-threshold transistors for designing the digital parts improves the comparator speed.

Polytechnique Montréal
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Professor: Yvon Savaria | yvon.savaria@polymtl.ca

A MASH 2-2 Noise Shaping SAR (NS-SAR) ADC

Applications include: Aerospace

The main objective is to propose a high-resolution ADC based on noise shaping SAR (NS-SAR) structure. The MASH architecture was used to increase the noise-shaping order of NS-SAR ADCs without increasing the filter order and opamp's gain in the feedback loop.

Polytechnique Montréal
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Professor: Yvon Savaria | yvon.savaria@polymtl.ca

Radiation Effects Studying on PLLs and VCOs using FDSOI 28nm Technology
Applications include: Aerospace, Automotive, defence (Safety, Security)

PLLs have been widely used in different applications, such as frequency synthesis, clock recovery circuits, local oscillator (LO), frequency generators, etc. The main function of the PLL is to produce an output signal at a specific frequency. A PLL generally comprises a phase detector (PD), charge pump, loop filter, a voltage-controlled oscillator, and a fractional divider. For electronic systems applied in space applications, PLL circuits are exposed to various sources of radiation that can have a catastrophic effect on their performance. The single event transient (SET) effects induced by radiation particles will impact the performance of the PLL circuits, causing a phase noise degradation or frequency shift. It in turn may cause the loss of PLL frequency lock, generally due to failures in the operation of the charge pump or the VCO, which are the most sensitive blocks in the entire system at the presence of single event effects. If the CP is hardened-enough to SETs, the VCO becomes the most sensitive block, causing the majority of the single event transients (SETs) generated in the PLL.

In this project, different sensitive sub-circuits of the PLL will be designed and tested to investigate their radiation sensitivity. Two different voltage-controlled oscillators will be implemented and tested to identify their advantages regarding functionality and radiation tolerance. First a Voltage controlled Ring Oscillator with current level control will be implemented to study the relationship between current levels and SET. Additionally, a multi-pass differential VCO will be fabricated as a possible hardening technique. LDO and op amps are also designed and embedded in the PLLs to achieve better performance in terms of less jitter and stability. Finally, two fully integrated PLL in FDSOI 28nm process will be implemented for radiation analysis, taking advantage of some characteristics offered by this technology.

University of Saskatchewan
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Professor: Li Chen | li.chen@usask.ca

Technology: 28-nanometer Bulk CMOS

TSMC 28nm HPC+

Neural Recording Chip for Epilepsy Monitoring
Applications include: Health/Biomedical

This project aims to design the electronics of a cortical implant for seizure forecasting up to 24 hours before occurrence for people suffering from epilepsy. The forecasts will enable patients to take precautionary measurements to prevent injury and allow time-specific treatment. The system is composed of four neurorecorders wired to a central hub. The ASIC submitted in this request for manufacturing is the central part of the neurorecorder. Each implant consists of a neural recording ASIC encapsulated in a biocompatible package with its ancillary electronics, implanted into the brain.

More specifically, the neural recording chip is a mixed-signal ASIC consisting of an array of 49 pixels individually coupled to 49 low-noise amplifiers that can acquire neural spikes with an amplitude up to 1 mV with noise not exceeding 5 uV. These spikes are digitized with a shared ramp ADC then processed with a digital controller that compresses, serializes and transmits the data via a wired link. The controller digital spike compression unit enables high resolution recording with a reduced outgoing data rate and hence low power consumption.

Université de Sherbrooke
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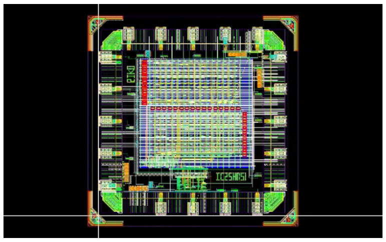
Professor: Réjean Fontaine | rejean.fontaine@usherbrooke.ca

Neuromorphic System-on-Chip

Applications include: Health/Biomedical, ICT (Artificial Neural Networks/Edge computing)



Our aim is to develop the first neuromorphic processor in analog and mixed signals CMOS in our research group. The neuromorphic system-on-chip or NeuroSoC will be used as an intelligent controller for our medical devices such as PET medical scanners, retinal implant, epilepsy implant, etc. The plus-value of the project is the low power and low area processing unit footprint compared to a classic Von-Neuman architecture. The medical application on which it will be tested will be the retinal implant algorithm to process visual data.

This project is the first proof of concept for this neuromorphic design in CMOS. This project will include several different neurosynaptic building blocs such as leaky integrate ad fire neurons and mixed signal synapses as well as a minimalistic spiking neural network SNN with one hidden layer. The size of the first network will be 16 spiking neurons at the input layer, 16 spiking neurons at the hidden layer and 10 spiking neurons at the output layer. The configuration of the SNN will be fully connected which means that between the first two layers we will have 256 excitatory and 256 inhibitory synapses. Finally, between the hidden and output layer we will have 160 inhibitory and 160 excitatory synapses. This first proof of concept SNN will serve as a platform to execute different neural networks trained offline and optimized for on-edge inference.

Université de Sherbrooke
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Optical TIA (I) and QA TIA (II)

Applications include: ICT

In the era of 5G and 6G, optical communication will play an important role in the definition of backhaul connections. In particular, CMOS will be the key to drop the costs. Unfortunately, nowadays optical RF front-end are mainly based on BiCMOS technology due to the stringent system requirements. This research aims to overcome CMOS limitations using a novel mixed signal processing named quantized analog signal processing.

The proposed design is a novel Transimpedance Amplifier for Optical communications with a 3dB bandwidth of 60GHz while consuming only 25mW (less than half of the state of the art of CMOS solutions). Based on a quantized analog signal processing, best in class THD and noise are obtained

University Of Toronto
Professor: Antonio Liscidini | antonio.liscidini@utoronto.ca

RF-Opto CMOS Driver (I) / QA CMOS Driver (II)

Applications include: ICT

In the era of 5G and 6G, optical communication will play an important role in the definition of backhaul connections. In particular CMOS will be the key to drop the costs. Unfortunately, nowadays optical RF driver are mainly based on BiCMOS technology due to the stringent system requirements. This research aims to overcome CMOS limitations by the use of a novel mixed signal processing named quantized analog signal processing.

The proposed design is Optical CMOS driver able to drive a Mach-Zender modulator with an output swing 2V peak-to-peak with a THD of only 1% and a bandwidth of 60GHz.

University Of Toronto
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Technology: 65-nanometer CMOS

TSMC 65nm CMOS

A Distortion Suppression Technique for a Digital Class D Audio Power Amplifier with Pulse Density Modulation
Applications include: Entertainment, Health/Biomedical

A novel distortion suppression technique suitable for digital class D audio power amplifiers using pulse density modulation (DSM). The distortion suppression circuit generates a digital measurement of the output stage error and feeds it back to the DSM for noise shaping. The intended application for this technology is battery powered audio, so the quiescent power of the overall amplifier system is below 1mW.

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A Highly Linear Phase Interpolator
Applications include: ICT

High linearity, 9-bit, 8 GHz phase interpolator for clock and data recovery application.

University of British Columbia
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CMOS Controller for Silicon Photonics Neuromorphic Computing
Applications include: ICT (quadratic computing; non-linear optimization)

CMOS control loop for in resonance photoconductive heater based microring resonators weight bank. The weight bank is the key element that sets the value of each neuron weight. The controller can accommodate up to 2 neurons.

University of British Columbia
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CMOS Random Number Generator
Applications include: Defence (Safety, Security)

Secure communications have been an important issue for over a century. With the number of connected devices constantly increasing, the need for generating encryption keys is constantly growing and the demand for circuits capable of generating these keys securely is growing at the same time. The goal of the project is to fabricate a novel random number generator for which the risks of intrusion, decryption and hacking is extremely low using a low-cost CMOS technology.

École de technologie supérieure
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Communication Hub Chip for Epilepsy Monitoring

Applications include: Health/Biomedical

This project aims to design the electronics of a cortical implant for seizure forecasting up to 24 hours before its occurrence for people suffering from epilepsy. The forecasts will enable patients to take precautionary measurements to prevent injury and allow time specific treatment. The system is composed of four neurorecorders implanted into the brain and wired to a central hub. Each neurorecorder consists of a neural recording ASICs encapsulated in a biocompatible package with its ancillary electronics. Those four neurorecorders communicates the neural activity information to the Central Communication hub implanted between the skull and the skin.

The ASIC, submitted in this application, is part of the communication hub. It aims to validate the design of the custom low power "pulsed' communication link between the satellite neurorecorders and the hub, consisting of a pulse generator on the neurorecorder side and a data receiver on the communication hub side. More specifically, the design consists of four pulse generators to emulate the transmitters circuitry on the four neruorecorder satellites and four receiver blocks to acquire the data and transfer it to the subsequent stages in the communication hub. These custom receiver and transmitter enable a low power communication link owing to the power consumption required only on the transition edges of short pulses.

Université de Sherbrooke
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NOEMA: Enabling portable and scalable processing of high-resolution brain activity for diagnostics, treatment, and augmentation of brain function

Applications include: Health/Biomedical, Pharmaceutical

NOEMA is a small form-factor, low energy, silicon hardware architecture that can detect events of interest in the brain in real-time. This "pattern detection" functionality is an essential processing block for a broad spectrum of applications such as prosthetics, treatment of neurological conditions, and drug discovery. While advances in neuroprobing technology presently allow us to capture the activity of thousands of neurons in real-time, pattern detection implementations have not kept pace. Today, real-time pattern detection is only possible for a few hundreds of neurons. NOEMA is a hardware-friendly implementation of an established pattern detection algorithm that processes in real time the activity of tens of thousands of neurons. The proposed prototype implementation will be capable of detecting up to 4 different experiences and from up to 30,000 neurons in real-time.

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Design of a Noise-Matched RF Oscillator for Quantum Computing Applications

Applications include: ICT (quantum computing)

The proposed circuit will use low-noise-amplifier (LNA) design techniques to optimize the phase noise of an RF oscillator. This will provide a novel design technique to design oscillators with lower phase noise than possible with traditional techniques.

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Dynamic Damping in TIAs

Applications include: ICT

To increase the Vertical Eye Opening (VEO) gain of the front-end of receivers in optical communication, the damping factor of the TIA (which amplifies and converts input data currents to voltage) is modulated.

Concordia University
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Professor: Glenn Cowan | gcowan@ece.concordia.ca

Low-power, Low-energy, Static CMOS Flip-flops

Applications include: ICT, Other (Low-power and low-energy have become overreaching requirement for portable, and wearable applications to increase its battery life. Flip-flops are the key components of digital circuits and affect the overall behavior of digital system. Thus, ultra-low-power and ultra-low-energy flip-flops would improve the overall performance of digital circuits.)

Ising machine would have wide applications in industry from low-power robotics to high-performance-computing datacenter applications. This test chip will have at least three different components: (i) Low-power, low-energy, single clock-phase, static flip-flops (ii) Low-power SRAM memory for low VDD, and (iii) Novel analog oscillator ising machine circuit for approximating solutions to certain np-hard optimization problems.

University of Waterloo
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Professor: Manoj Sachdev | msachdev@uwaterloo.ca

Power Management Module and Current Source for an ASIC

Applications include: Health/Biomedical

The project aims to develop an ASIC for biomedical application. In this part we plan to develop and test a management module and a current source required to be used in the ASIC.

McGill University
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System-on-Chip (SOC)

Applications include: ICT

This design contains a fractional N synthesizer and a VCO-based ADC for a full duplex self interference cancellation (SIC) radio. The synthesizer provides a tunable LO for the SIC clocking circuits, while the low frequency ADC is used for calibration and control of SIC filters.

University of British Columbia
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Professor: Sudip Shekhar | sudip@ece.ubc.ca

The Memristor Project
Applications include: ICT (Artificial Intelligence Enhancement Techniques)

Self Programming FG Device

Polytechnique Montréal
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Ultra Low Flicker Noise and Highly Linear UWB Down-Conversion Mixer for OFDM Applications
Applications include: ICT (wireless communication)

In this design, a novel highly linear Gm-switched (GmSw) down-conversion mixer has been proposed to eliminate the effect of asymmetric transistors in switching stage of Gilbert mixer alongside the extreme flicker noise corner frequency reduction. Using RC degeneration and switchable double balanced transconductance with one switch structure for each LO period can meet our demands about second/third order linearity and low frequency noise level. The proposed mixer with an UWB input matching circuit in 3-6GHz bandwidth has been simulated in 65nm CMOS TSMC technology with 1V power supply while the power consumption is 8.5mW and maximum Conversion Gain (CG) is 7.4dB. IIP2 and IIP3 parameters are evaluated with Monte-Carlo simulation (sampling method: Low Discrepancy Sequence) and have the mean value of 92dBm and 5.8dBm in whole of the bandwidth, respectively. By using Monte Carlo simulation, 1/f corner frequency is remarkably degraded to under 1KHz.

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Ultra-wideband mmwave Passive Phase Shifter
Applications include: Agriculture/Agri-Food, ICT

In this project, we will design multi ultra-wideband (UWB) passive phase shifters which are capable to cover full FR2 frequency range of 5G/6G application and provide full 360-degree phase shift. Such phase shifters can be used in phased array systems to provide flexible and high-resolution beam steering.

The proposed phase shifters are constructed based on Tunable Transmission Line (TTL) method. These phase shifters offer a linear and high resolution while consuming no power. However, the drawbacks of these phase shifters are high insertion loss and large chip area which will be addressed in this project. In our work, we design three different TTL phase shifter. The first one is based on the classic design, and it will be used as the reference design. On the other hand, the other two use two different innovative methods to improve the performance in the terms of reducing Insertion Loss and the chip area.

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Wide Band Harmonic Rejection Receiver Using a Non-overlapped Clocking Scheme

Applications include: ICT (Wi-Fi in the 6 GHz band)

The unlicensed spectrum in the 2.4 and 5 GHz bands has led to the exponential growth of Wi-Fi. It is expected that Wi-Fi networks will carry almost 52% of global IP traffic by 2022, more than any other wireless technology. Also, the Wi-Fi Alliance has predicted an 800 MHz spectrum shortage by 2020, increasing to 1.12 GHz by 2025. To address this, the FCC has proposed widening the spectrum available for unlicensed usage in the 5.9 - 7.1 GHz band. Accordingly, wireless systems and devices should be able to efficiently support the higher bands and new standards used in upcoming applications. This puts a strain on the RF front-end specifications, and many wideband transceivers have been proposed for different wireless standards operating in a wide range of frequencies, from MHz up to GHz.

There is a strong motivation to create a low-noise, wideband, low-power and low-cost receiver front-end that is able to support the 5.9 - 7.1 GHz frequency band. The proposed receiver front-end uses harmonic rejection non-overlapped clocking strategy. The proposed harmonic rejection (HR) receiver utilizes a non-overlapped clocking scheme that tunes the duty cycle in a single-path receiver to realize a notch frequency. In this HR receiver, the 1st, the 2nd, and 3rd notches are placed at the 1st, 5th and 7th harmonic frequencies, respectively. In the proposed technique, instead of utilizing N-path filtering and harmonic recombination at the baseband to reject the unwanted harmonics, a harmonic rejection non-overlapped clocking scheme with a reset switch during the non-overlapping time is utilized in a single-path topology. The proposed receiver has lower complexity and achieves low power consumption. Our design aim is to create a fully integrated receiver RF front-end, which is able to cover wide frequency range and to support a 5.9 - 7.1 GHz band.

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Wideband Galvanic Isolated Current Sensor

Applications include: ICT

Galvanic isolation is used in wide-ranging voltage and current sensing applications. This work proposes a wideband galvanic isolated VCO-based current sensing architecture. Some of the key challenges to achieve a robust design are: high linearity and wide bandwidth. The target for this project is to achieve a bandwidth between 5 to 10 MHz, which is significantly larger than the bandwidth achieved in currently published studies (1 MHz). This design will also feature a frequency demodulation method that directly demodulates the RF voltage signal to an analog voltage signal without digitizing the signal at the output.

Carleton University
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Technology: 90-nanometer SiGe BiCMOS

GF9HP

A High Speed and Low Noise Optical Receiver Design

Applications include: ICT

This project aims to develop high speed and low noise optical receivers to serve modern data center and telecommunication applications. BiCMOS is used to implement front end transimpedance amplifier (TIA). Multistage architecture is developed along with bandwidth extension circuitry to achieve high gain for high data rates while achieving less input referred noise.

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Technology: 130-nanometer CMOS

TSMC 0.13µm CMOS

3rd Generation DNA Sequencing Mixed-Signal CMOS Readout Chip

Applications include: Agriculture/Agri-Food, ICT, Health/Biomedical, Pharmaceutical

The project seeks to demonstrate a next-generation mixed-signal CMOS readout circuit for "3rd generation" (3G) DNA sequencing machines. Modern sequencers can operate directly on DNA samples and convert them to electrochemical current equivalents in real-time using nanosensors called nanopores. This comes with many advantages (and challenges), most notably a +100X reduction in technology size, an advance that is allowing mobile DNA sequencing. To process these measurements a mixedsignal readout chip is needed to amplify the minute current (10s of pA) and digitize it. Such a readout chip is the focus of this design. The primary objective of this design is to greatly extend the rate (+10X bandwidth boost) at which such a chip can work for biological nanopores without compromising noise performance or power consumption. This boost will allow DNA measurements to be conducted at commensurately higher rates.

York University
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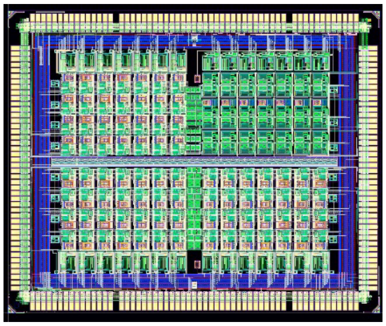
10x10 Mixed-Signal High-Speed DNA Sequencing Array

Applications include: Agriculture/Agri-Food, Health/Biomedical, ICT, Pharmaceutical



The project seeks to demonstrate a next-generation mixed-signal CMOS readout circuit for "3rd generation" (3G) DNA sequencing machines. Modern sequencers can operate directly on DNA samples and convert them to electrochemical current equivalents in real-time using nanosensors called nanopores. This comes with many advantages (and challenges), most notably a +100X reduction in technology size, an advance that is allowing mobile DNA sequencing. To process these measurements a mixed signal readout chip is needed to amplify the minute current (10s of pA) and digitize it. Such a readout chip is the focus of this design. The primary objective of this design is to greatly extend the rate (+10X bandwidth boost) at which such a chip can work for biological nanopores without compromising noise performance or power consumption. This boost will allow DNA measurements to be conducted at commensurately higher rates.

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A Low-Power Signal-Dependent Sampling Technique

Applications include: Automotive, Health/Biomedical, ICT, Natural Resources/Energy

The main objective of this project is to design an ultra-low-power Analog-to-Digital converter (ADC) for wireless sensors and biomedical implants. In this project, a non-uniform signal-dependent sampling (SDS) technique is proposed. The idea is to reduce the number of required sampling points of an input signal whenever the signal is not changing significantly in order to save power for longer battery life. The designed SDS block is placed before ADC and determine when ADC should be enabled or disabled. The SDS block detects the valuable points to be retained and dropped all others. Then, the signal will be reconstructed by drawing direct lines between the accumulated retained points.

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A Low-Power Wideband Receiver Front-End for IoT Applications

Applications include: ICT, Other (Internet of Things (IoT))

There is a strong motivation to create a low-noise, wideband, low-power and low-cost receiver front-end that is able to support both local and wide area networks for internet of things (IoT) applications. The proposed design is a current-reuse RF to baseband receiver front-end. It mainly consists of cascoding transimpedance amplifier on LNTA to share DC biasing and using a single supply along with a passive mixer to down-convert an RF signal to an IF signal. In addition, a noise cancelling technique and active inductor enhance the noise performance in order to increase the sensitivity of the receiver and make it suitable for both local and wide area networks. Our design aim is to create a fully integrated receiver RF front-end, which is able to cover a wide frequency range and to support several standards such as NB-IoT and Bluetooth low energy.

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A Wireless Implantable Energy Efficient Activity-Adaptive Neurophysiological Sensing SoC

Applications include: Health/Biomedical

The goal of this project is to design and implement an energy-efficient activity-adaptive brain-implantable system on a chip (SoC) for recording brain’s activity. The SoC will be fully wireless and consists of 16 neural-interfacing channels with low-power, low noise, and high-resolution specification. In this system, brain activity is recorded and processed in real-time. The data is recorded with a second-order continuous-time delta-sigma ADC. The ADC's output is fed to an in-channel signal processing block that evaluates the recorded neural signals level of activity and adjusts the oversampling ratio of the ADC in a responsive manner. This results in the ADC's quantization resolution to be adaptive to the input signal's activity level. Thanks to the fully dynamic power of the described mixed-signal recording architecture, the resolution adaptivity is directly translated into power adaptivity. Considering the sparsity of the brain neural activity (i.e., very low activity level for the majority of the time), this feature will significantly reduce the overall acquired data that needs to be transmitted. Consequently, this relaxes the data rate requirement of the wireless data transmitter, which is the most power-hungry block in an implantable device. The system’s functionality will be verified using in-vitro and in-vivo experiments in collaboration with neurologists at York University.

York University
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All Digital Delta-sigma TDC using Bi-directional Vernier Gated Delay Line Time Integrator

Applications include: Automotive, Defence (Safety, Security), Environment, Health/Biomedical

The proposed "all-digital delta-sigma time-to-digital converter(TDC) using bi-directional Vernier gated delay line time integrator" is implemented in TSMC 130 nm 1.2 V CMOS technology and analyzed using Spectre with BISM 4 device models. The simulation results of the proposed delta-sigma TDC exhibits first order noise-shaping with noise floor independent of the amplitude of the input. The dynamic range of the TDC is lower-bound by the difference between per-stage delay of the slow and fast lines and the nonlinearity of the delay stages of the time integrator and upper-bound by the number of stages of the time integrator. The utilized time integrator in the proposed design was presented at MWSCAS 2020 as shown below:

P. Parekh, F. Yuan and Y. Zhou, "All-Digital Time Integrator Using Bi-Directional Gated Vernier Delay Line," 2020 IEEE 63rd International Midwest Symposium on Circuits and Systems (MWSCAS), Springfield, MA, USA, 2020, pp. 321-324, DOI: 10.1109/MWSCAS48704.2020.9184630.

Toronto Metropolitan University (formerly Ryerson University)
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An Ultra-Low-Power Time-Domain Level-Crossing ADC with Adaptive Sampling Rate and Resolution

Applications include: Health/Biomedical, ICT, Natural Resources/Energy

In this design, a time-domain ultra-low micro-level power consumption ADC will be designed and fabricated. The proposed ADC realizes the level-crossing sampling technique on a time-domain ADC for the first time, taking a step future to reduce the power consumption. By doing so, it can achieve adaptive sampling rate and resolution. The proposed ADC can be used in various areas, for example, IoT, biosensors, sensor interface circuits, and so on. Since most components in time-domain ADCs are unit logic gates, it has an advantage that the power supply voltage can be reduced so that much power can be saved. With the help of adaptive sampling rate and resolution, it can save some needless conversion cycles and saves hardware by using a low-resolution TDC instead of a high-resolution one in the conventional time-domain ADCs, hence reduces the power consumption. The charge pump is selected as the candidate of VTC and DTC, the former one is used to convert the input voltage into a time-domain signal, while the latter one is used to create a time level that is used to do the comparison in the level-crossing scheme. For the TDC, Venier TDC has been chosen to replace the Flash TDC to future increase the accuracy and speed. When the input signal has slight changes or remains unchanged, the proposed ADC can switch to another status that most parts can be shut down in order to save power. For applications like sensing circuits, for most of the time, the input signal does not change, so that the proposed ADC is a good candidate for such applications.

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EM Canary Circuit 3.0

Applications include: Aerospace, Automotive, Entertainment

Canary circuit for Piezo resistive detection of Electromigration Void growth in VLSI interconnect with improved test structures.

University of Waterloo
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High-resolution CMOS Neural Interface for Synchronized Optogenetics and Electrophysiology (Phase III)

Applications include: Health/Biomedical

In this project funded by by NSERC, CIHR and the Weston Family Foundation (Brain Health), we are developing a complete high-resolution multimodal CMOS brain implant on a chip. This SoC will provide high-resolution multimodal electrophysiological recording, optogenetic photo-stimulation, and electrical stimulation capabilities within a single IC for studying brain microcircuits of mice by enabling synchronized brain stimulation and neural activity recording through a closed-loop system. In the phase I (design ICXLVOPT), we implemented an innovative multichannel analog-to-digital interface prototype for this SoC. This first IC includes a 4-channel low-power and low-dropout LED driver to illuminate light-sensitized neurons in the brain, a 10-channel low-noise and power efficient analog-front-end to collect the evoked bioelectrical activity, 10 in-channel low-power third-order MASH Sigma-Delta modulators for analog-to-digital conversions, a CIC4 decimation filter and a digital controller module to control all building blocks. In the phase II (design ICXLVPII), we added a low-power programmable digital controller to perform closed-loop optogenetic using the circuits developed in the phase I. This controller efficiently interfaces the first IC circuits and performs complex neural signal processing to effectively close-the-loop between the neural recording interface and the optical stimulator.

In the phase III (this design), we propose to improve the IC of phase II by adding circuits for 1) wireless power recovery and 2) for electrical brain stimulation. The circuits (1) are mandatory for the IC to be chronically implantable, while the circuits (2) will allow experiments with non-genetically modified rodents (i.e., not responsive to light stimulation). This proposed design represents the next step towards the realization of a complex implantable mixed-signal brain implant on a chip including a microcontroller and all the necessary modules to perform closed-loop stimulation within a single IC.

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High-resolution CMOS Neural Interface for Synchronized Optogenetics and Electrophysiology (Phase IV)

Applications include: Health/Biomedical

In this project funded by NSERC, CIHR and the Weston Family Foundation (Brain Health), we are developing a complete high-resolution multimodal CMOS brain implant on a chip. This SoC will provide high-resolution multimodal electrophysiological recording, optogenetic photo-stimulation, and electrical stimulation capabilities within a single IC for studying brain microcircuits of mice by enabling synchronized brain stimulation and neural activity recording through a closed-loop system. In the phase I, we implemented an innovative multichannel analog-to-digital interface prototype for this SoC. In the phase II, we added a low-power programmable digital controller to perform closed-loop optogenetics using the circuits developed in the phase I. This controller efficiently interfaces the first IC circuits and performs complex neural signal processing to effectively close-the-loop between the neural recording interface and the optical stimulator. In the phase III, we propose to add circuits for wireless power recovery and for electrical brain stimulation.

In this phase IV, we want to add multicore signal processing and increase the number of recorded/processed channel by a factor of 3 (30 channels). This proposed design represents the next step towards the realization of a complex high-resolution implantable mixed-signal brain implant on a chip including a microcontroller and all the necessary analog and digital modules to perform closed-loop stimulation within a single IC.

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Ku-band Rotary Travelling Wave Oscillator with Reliable Direction Control

Applications include: Automotive

This work focuses on the design of rotary travelling-wave oscillator (RTWO). A power conscious RTWO with reliable direction control of the wave propagation is investigated. The proposed RTWO consists of sixteen transmission line segments, designed and optimized with respect to the phase noise in an electromagnetic (EM) tool, targeting 15-20-GHz under PVT variations. The design is implemented in a standard 130 nm CMOS technology.

Lakehead University
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PVT Invariant Subthreshold Gm Reference

Applications include: Automotive, ICT, Health/Biomedical, Natural Resources/Energy

In this project, a process, voltage and temperature (PVT) invariant transconductance (gm) reference operating for subthreshold circuits is proposed. Operating circuits in the subthreshold region reduces power consumption by reducing the operating voltage and increasing the power efficiency. The development of circuits in this area is necessary to enable ultra-low power IoT and sensing devices for healthcare and environmental monitoring that can be solely powered using energy harvesting. The challenge for circuits operating in the subthreshold region is the increased sensitivity to PVT variations due to the exponential current-voltage relationship. This translates to large variations in the device transconductance that determine a number of main circuit parameters, such as the gain, frequency response and impedance matching. Conventional gm references suffer from short-channel effects that limits their ability to provide a constant gm. The proposed gm reference aims to minimizes short-channel effects to reduce sensitivity to PVT variations.

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PVT Invariant Ultra-Low Power Subthreshold LNA

Applications include: Automotive, Health/Biomedical, ICT

In this project, an ultra-low power low-noise amplifier (LNA) that is insensitive to power, voltage and temperature (PVT) variations for wireless sensors and mobile applications is designed. The designed 2.4 GHz LNA operates under subthreshold conditions and uses a current re-use technique to simultaneously lower power consumption and improve power efficiency. The LNA deals with the challenge of increased sensitivity to PVT variations when operating in the subthreshold region by developing the LNA as a reference circuit itself. The feedback within the LNA directly controls the response of the LNA to suppress the magnified PVT variations in the subthreshold region. This also reduces the power and area overhead associated with using a separate biasing circuit to enable higher efficiency and longer operation.

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Technology: 180-nanometer CMOS

TSMC 0.18µm CMOS

A Capacitive-Based Digital Isolation System Intended for Industrial Sensor Interfaces

Applications include: Aerospace

In this work, we propose a digital isolator utilizing pulse amplitude modulation scheme using capacitive coupling as an isolation barrier. The isolator consists of three main components: the transmitter, the barrier (in one die), and the receiver (in another die). It supports a single data communication channel. Firstly, the input digital signal from a microcontroller unit is transmitted using digital-to-analog modulation scheme through transmitter sub-blocks (i.e., pulse detector, voltage level limiters, and multiplexers). Then, a capacitive coupling on each die will be integrated to transfer the modulated signal to the bond pads, which then transferred from the low-voltage side to the high-voltage side through bondwires. At the receiver side, the Schmitt trigger circuit is used to generate the data and clock signals by comparing the high and low amplitudes of the received modulated signal. These two generated signals will be processed to a D Flip-Flop to reconstruct the digital signal at the output. This reconstructed microcontroller's input digital signal will be delivered to the Insulated Gate Bipolar Transistor (IGBT) gate driver at the high-voltage regime.

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A High Precision, High PSRR PVT Insensitive Bandgap Reference

Applications include: Health/Biomedical

Voltage reference circuits are one of essential parts in analog or mixed-signal circuits, especially in Analog to Digital Converter. To achieve high performance voltage reference, The proposed bandgap voltage reference with high precision and high PSRR is promoted. The proposed bandgap voltage is achieved by adding a conventional bandgap reference with proposed higher order compensation. The mechanism of the proposed curvature-compensation technique is verified thoroughly and the corresponding BGR circuit was implemented in standard CMOS 0.18µm technology.

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A High SNDR Low Power Open Loop VCO-ADC

Applications include: Health/Biomedical

Analog to digital converters (ADCs) are key components in many electronic systems. The voltage-controlled oscillator (VCO)-based ADC has been gaining popularity since it takes advantages of the timing resolution and also lends itself to a highly digital implementation and processing technique. VCO-based ADC could be implemented in closed-loop or open-loop topology. The closed-loop one achieves better linearity, with the price of the increased complexity. In this work, the open-loop architecture is chosen to have compact and low power consumption VCO-based ADC to be used as a low-noise sensor readout circuit and it focuses on increasing the linearity. This ADC is implemented in standard CMOS 0.18µm technology.

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A Lock-in Amplifier with Automatic Phase Alignment

Applications include: Health/Biomedical

One of the crucial tasks during continuous monitoring of respiratory mechanics using forced oscillation technique (FOT) is to accurately extract the FOT signal. Typically, this process is carried out by a conventional bulky speaker and higher order of FOT signal amplitudes at low FOT frequencies (<10Hz).Followed by a Pneumotach pressure and flow sensing, the resistance (real part) and the reactance (imaginary part) are obtained and further analyzed to extract information about the respiration behavior. Thus, FOT helps to diagnose and monitor various respiratory disorders, e.g., cessations in respiratory rhythm or reductions in breathing amplitude, i.e. sleep apnea.

To miniaturize this system, the FOT frequency need to be increased (to shrink the speaker) and its amplitude needs to be reduced for more patient convenience and ultra-low power (i.e., longer battery life). However, the signal-to-noise ratio (SNR)needs to be at acceptable level for such application which is challenging in the presence of breathing noise floor. Therefore, the proposed design implements a lock-in amplifier(LIA) as an analog front end to extract the known FOT signal even though it is buried under noise floor. In contrast to previous works, this approach is integrated with the ability to work at much higher frequencies which means portable device projection. Beside accuracy, power dissipation is another important factor to be considered when designing bioelectronics. As such, in this system the filtering part will be implemented based on switching capacitor. The LIA figures of merit include power dissipation, SNR, and die area.

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ASIC LabPET Scanner with Crystal Identification

Applications include: Health/Biomedical

This project aims to design a prototype of the new Ultra High spatial Resolution (UHR) positron emission tomography (PET) imaging scanner. The UHR scanner is the latest PET imaging scanner being designed at Université de Sherbrooke for brain imaging, based on the LabPET II technology platform developed to achieve high spatial resolution imaging using fully pixelated APD-based detectors and highly integrated parallel front-end processing electronics.

This project will improve the LabPET II technology by enabling Depth-of-Interaction (DOI) capability for better and more uniform spatial resolution about 1.25 mm within large Field-of View as for brain scanner. The ASIC submitted in this run include all the previous featured added in the ICFSHFE5 revision but fixes 2 bugs we found in the previous run. So, the missing code bug in the ADC for amplitude extraction was fixed., and the bug in the communication link at high data rate and simultaneous command and data was fixed. This run is to experimentally validate all the upgrades done in this design before fabricating the thousands of dies required to fully assemble the UHR scanner.

Université de Sherbrooke
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Designing a Stable and Reconfigurable DC-DC Converter
Applications include: Automotive

The goal of the project is to design a step-down DC to DC converter, that is suitable for avionics application. The concept of the conversion works as follows: The output voltage, and reference voltage are each fed back to a voltage-controlled oscillator, which converts the voltage to frequency. The frequencies are then compared by the means of phase frequency detector, which will generate the up and down signals based on which frequency is higher. Then the output of phase frequency detector is fed to a charge pump and a low pass filter, which will generate an analog voltage which increase when we have an up signal and decrease in the case of a down signal. The analog voltage is then converted to pulse width modulated signal which is send to deadtime control and gate driver to feed the DC converter. The system will have the DC signal, bias voltage, reference voltage and clock signal as input and will generate a step-down DC voltage as output.

Polytechnique Montréal
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High-speed and High-sensitivity Imaging Sensor for positron Emission Tomography Applications
Applications include: ICT, Health/Biomedical

Cancer is one of the main causes of death in Canada. In order to diagnose cancers at the early stage, medical imaging techniques including X-ray computed tomography (CT), magnetic resonance imaging (MRI), ultrasound imaging (UI), optical coherent tomography (OCT), and positron emission tomography (PET) have been employed. Among these imaging technologies, PET has become one of the most powerful tools to acquire functional images due to its high sensitivity to differences in the metabolic and biological activities at the molecular level. One of the key components of a PET imaging system is the photosensor in the PET detector.

In this project, we plan to use the standard CMOS technology (TSMC 180 nm) to design and investigate one of the most sensitive silicon detectors – the digital Silicon Photomultiplier (dSiPM), which incorporates single photon avalanche diodes (SPADs) for low-level light detection and high-speed digital circuitry for accurate timing information. In this design, we focus on investigating 2 aspects of SPADs: new guard ring structure and photon detection efficiency (PDE). Through the design, optimization, fabrication and measurement of the SPAD, we hope to achieve the following primary objectives.

- Optimize the design of SPADs in the standard CMOS technology for the PET applications.
- Study and design the front-end circuits like quench and reset circuits for SPADs.
- Investigate techniques for the integration of the SPADs with signal conditioning and processing circuits.

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High-speed LDO with Frequency Compensation and Slew-rate Enhancement
Applications include: Automotive, Entertainment

The main objective of this design is to meet requirement for high-speed digital system on chip, where there will be large transient current changes within short time, e.g., ns, with relative large load capacitor. The proposed LDO uses passive-active frequency compensation technique to minimize compensation capacitance and speed up transient response by increasing the closed-loop bandwidth. A transient current regulation circuit is designed to further improve the dynamic response of the LDO.

Lakehead University
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Leakage-Compensated Single-Photon-Counting Pixel for a-Se/CMOS X-ray Imagers

Applications include: Health/Biomedical

Offsets produced by leakage current through the amorphous selenium (a-Se) X-ray sensor layer in a-Se/CMOS imagers cause errors in multi-spectral single-photon-counting pixels. These errors reduce the performance of "colour X-ray" systems used in medical diagnostics. To combat this issue, we will implement a new approach to leakage current compensation in single-photon-counting pixels that has minimal impact on pixel dimensions and complexity. Our design will implement a small array of pixels and compensation circuits to fully demonstrate our approach. This work is part of a series of designs related to developing new a-Se/CMOS multi-spectral X-ray imagers. This is an update to a previous design.

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Microwave Integrated Sensor

Applications include: Health/Biomedical

Low-power high-resolution liquid and solid particles detector at 5 GHz frequency spectrum.

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RISC-V Based Processor Architecture for an Embedded Visible Light Spectrophotometer

Applications include: Health/Biomedical

The sensing of neurotransmitters is a current challenge in the field of biomedical research. The design of a new compact and accurate sensor would benefit greatly the research being done on neurotransmitters. The field of optics was chosen for the sensor because it is non-invasive and does not alter the sample while testing. The use of optoelectronic sensors is very useful in that regard especially by using visible-light spectroscopy for molecular detection. The basis for this sensor’s geometry is the Grism. The system was designed at first to be either in transmission or reflection depending on the type of grating chosen in the Grism. For the tests in the laboratory, the transmission geometry was chosen and adapted to fit commercially available components. The system was then assembled and calibrated to measure its resolution as well as spectral range. An image sensor that is programmed to be self calibrating and user friendly was also fitted to the system.

A RISC-V core with 256MB of embedded memory is attached to the required SPI, I2C and UART peripherals to enable edge computing for a visible light spectrophotometer which uses a OV5642 sensor camera at around 200fps. The processing application requires a processor than can perform image processing and neural network computations very quickly. This design connects the core's cache along with debugging interfaces to the memory and memory-mapped peripherals through a 64bit wide AXI4 crossbar to enable testing of the architecture. A multicore RV64 core with F and D extensions is used to provide a powerful computing environment. We choose this architecture for the ease of implementation as well as the additional computing performance for potential graphics processing applications. A flexible architecture that easily allows the addition or removal of cores is an advantage over other open source cores since it will be possible to tune the design's power requirements and computing power for further versions.

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Professor: Amine Miled | amine.miled@gel.ulaval.ca

SAR ADC for Ice Sensing Readout System
Applications include: Aerospace, Natural Resources/Energy

A customized 100 kHz 10-bit SAR ADC for a saltwater ice sensing platform.

University of British Columbia
Designer: Katherine Luckasavitch | k.luckasavitch@alumni.ubc.ca
Professor: Mohammad Zarifi | mohammad.zarifi@ubc.ca

Single Photon Avalanche Diode Array Readout Circuit
Applications include: Health/Biomedical, ICT (High Energy Physics)

The Groupe de Recherche en Appareillage Médical de Sherbrooke (GRAMS) is working on Single Photon Avalanche Diode (SPAD) based photodetectors integrated in 3D over CMOS electronics. The 3D architecture allows having heterogenous technologies (e.g., optoelectronics coupled to high-end CMOS electronic readout) and hence maximize the detector's performance. The market of these photodetectors is found in many applications such as medical imaging (positron emission tomography), 3D cameras and low light/low background physic experiments.

The proposed design is crucial for developing the optoelectronic layer (the SPAD layer) since it will be used as the SPAD readout electronics for their characterization. Of course, the GRAMS already has other SPAD readout circuits (for example in 65 nm), but these circuits can only be used in a 3D configuration, meaning a fully developed SPAD layer and a 3D bonding process. Furthermore, they have limited high voltage capabilities (3.3V max). The proposed readout circuit, built in the TSMC 180 nm BCD CMOS technology, will allow the SPAD to be tested either in a 2D or in a 3D configuration with a higher voltage range for a complete SPAD characterization. This circuit is mandatory for the SPAD development line. It will provide a SPAD test bench with different types of quenching circuits containing low-jitter comparators. Therefore, SPAD properties will be studied with these circuits such as Dark Count Rates (DCR), Single Photon Timing Resolution (SPTR), Photon Detection Efficiency (PDE), crosstalk, afterpulse and so forth.

Université de Sherbrooke
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Professor: Jean-François Pratte | jean-francois.pratte@usherbrooke.ca

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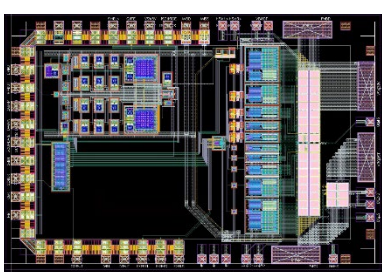
Smart Gate Driver Topologies for SiC Power Modules
Applications include: ICT (Energy and Automation)



This project proposes a silicon carbide power MOSFET gate driver with integrated aging detection sensors. Characterisation of the switching transients at the gate of the power MOSFET using slope detection will reveal performance degradation of aged devices and trigger an integrated compensation circuit to correct the gate drive strength. The proposed aging detection and compensation mechanisms are designed for online SiC MOSFET performance correction. Control of the gate driver will be achieved via an integrated digital logic circuit.

University Of Toronto
Designer: Mengqi Wang | mengqi.wang@mail.utoronto.ca
Professor: Wai Tung Ng | ngwt@vrg.utoronto.ca

Smart Gate Driver Topologies for SiC Power Modules for Continuous Aging Detection and Compensation
Applications include: ICT (Energy and Automation)

This project proposes a gate driver for silicon carbide (SiC) power MOSFET with integrated aging detection sensors. Characterization of the switching transients at the gate of the power MOSFET using slope detection will reveal performance degradation of aged devices and trigger an integrated compensation circuit to correct the gate drive strength. The proposed aging detection and compensation mechanisms are designed for continuous SiC MOSFET performance correction. Control of the gate driver will be achieved via ADC sense and digital logic circuits.

University Of Toronto
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Technology: 180-nanometer High-voltage CMOS

XFAB XT018

A High-frequency Mixed Signals Control System for Zeta Converters
Applications include: Aerospace

This project presents a mixed-signal design of the control system used for the Zeta converters. In this approach, time is used as the processing variable, where voltage-mode and current-mode DC-DC converters are controlled by time-domain circuits, including voltage-controlled oscillators (VCOs), phase detectors, and voltage-controlled delay lines. This eliminates the need for wide bandwidth amplifiers, voltage comparators, and high-resolution ADCs, which results in lower power consumption, higher efficiency, and smaller silicon area. The proposed design aims to enhance the output voltage accuracy and exhibits small area and power consumption. In addition, this mixed signal control system will be working at high frequency to allow minimizing the size of the LC filter in the converter. Moreover, a multi-phase approach is employed to ensure the stability and low noise output.

Polytechnique Montréal
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Configurable Integrated Power Input/Output Systems for Avionic Applications (I & II)

Applications include: Aerospace

This main goal of this work is to design a high-voltage (200V) smart gate driver for multi-MHz GaN-based DC-DC converters in avionic applications. The novelty of the gate driver is its reconfigurable architecture and novel internal subblocks, enabling the proposed gate driver to fully leverage the GaN devices' figure of merit.

(I) An active-coupled level shifter with high dV/dt slew immunity is designed. On-chip configurable buffers control the driving strength to optimize the converter's power efficiency and electromagnetic interference (EMI). A configurable dead-time generator adjusts the deadtime to an optimal value to reduce the DC-DC converter loss. Furthermore, low-power and high-accuracy under-voltage lock-out (UVLO) and thermal shutdown (TSD) circuits are also included. These circuits help to protect the gate driver from under voltage and over-temperature conditions, enhancing the reliability of the gate driver and DC-DC converters. As the proposed gate driver integrates various features onto a single chip and can be reconfigured without adding many external components or modifying the hardware design, the proposed gate driver can help to reduce the overall cost and design efforts of high-performance DC-DC converters at the system level.

(II) A novel capacitive-coupled sub-ns delay high dV/dt slew immunity level shifter is proposed. The level shifter helps to extend the frequency range as well as the operating voltage domain of gate driver. Thus, DC-DC converter's frequency can be up to tens of MHz. On-chip configurable buffers control the driving strength to optimize the converter's power efficiency and electromagnetic interference (EMI). Besides, an on-chip active EMI reduction scheme with spread-spectrum modulation technique is implemented. Furthermore, an adaptive deadtime controller is also embedded that automatically adjust the deadtime to an optimal value to reduce the DC-DC converter loss. Finally, low-power and high-accuracy under-voltage lock-out (UVLO) and thermal shutdown (TSD) circuits are also included. These circuits help to protect gate driver from under voltage and over-temperature conditions, enhancing the reliability of the gate driver and DC-DC converters. As the proposed gate driver integrates various features onto a single chip and can be reconfigured without adding many external components or modifying the hardware design, the proposed gate driver can help to reduce the overall cost and design efforts of high-performance DC-DC converters at the system level.

École de technologie supérieure
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Fully integrated Capacitive Coupling Digital Isolator for Aerospace Applications

Applications include: Aerospace

This work proposes the pulse amplitude modulation scheme adopted for a projected capacitive coupled digital isolator. The isolator consists of one data communication channel formed of two dies. For the first stage, the input digital signal form a microcontroller unit is processed using digital-to-analog modulation scheme through transmitter blocks (i.e., pulse detector, delay elements and multiplexers). Then, capacitive coupling on each die (transmitter and receiver) will be integrated to transfer the modulated signal to the bondpads, which then transferred from the low-voltage side to the high-voltage side through bondwires. The third stage is to design the building blocks at the receiver side, the comparator will be designed to generate the set and reset digital signals by comparing the high and low amplitudes of modulated signal. These two generated signals will be processed to the SR Flip-Flop to reconstruct the digital signal at the output. This reconstructed microcontroller's input digital signal will be delivered to the Insulated Gate Bipolar Transistor (IGBT) gate driver at the high-voltage regime.

Polytechnique Montréal
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High-Side and Low-Side Versatile Integrated Power Sensor Interface

Applications include: Aerospace

This project aims to build integrated versatile sensor and actuator interface solutions in avionic applications. These interfaces are mainly composed of synchronous DC-DC converters (buck topology or buck boost topology). The interfaces will stabilize the variable input supply coming from the plane and drive the different actuators and sensors available. This design is a versatile gate driver used to drive external wide-bandgap semiconductors power transistors (GaN). It will also include on-chip integrated power transistors in the form of half-bridge to support full integration of the system and compare to the use of off-the-shelf power components. The primary objective is to test some innovative ideas in the design of gate driver building blocks and evaluate X-FAB technology to better exploit its capabilities.

Polytechnique Montréal
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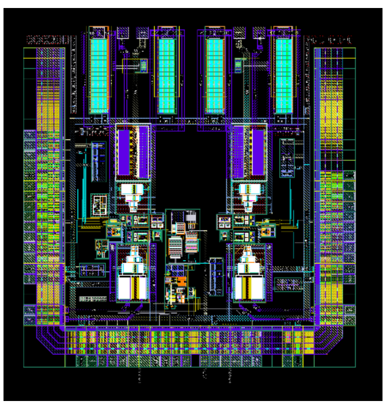
High-Side and Low-Side Versatile Power Sensor Interface

Applications include: Aerospace



This project aims to build an integrated versatile sensor and actuator interface solution in avionic applications. The main block of this interface is a synchronous DC-DC converter (buck-boost ZETA topology). It will stabilize the unregulated input supply from the airplane and drive a wide range of inductive resistive loads (actuators). The design includes a versatile novel dual-channel gate driver used to efficiently drive external wide-bandgap semiconductors GaN power transistors. It also includes a fast analog voltage feedback combined with feed-forward configuration to achieve better line and load regulation. The primary objective is to test some innovative ideas in the design of gate driver architecture and the various building blocks. In addition, we aim to verify a novel design method of combining different feedback mechanisms. This chip complements the first chip we fabricated in X-FAB technology.

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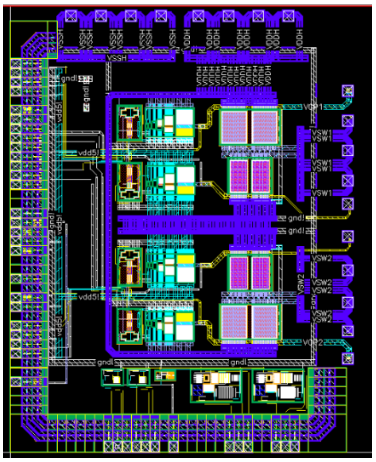
High Voltage Full-bridge Closed Loop Class-D Power Amplifier for Aerospace Applications

Applications include: Aerospace



The goal of this project is to implement a high voltage fully integrated closed loop full-bridge class D power amplifier circuit that provides a configurable output waveform. The proposed design generates a staple output DC voltage according to the required voltage level, where the voltage level is controlled through the reference voltage in the feedback part. This generated output is used to drive aircraft's actuators including resolvers, force and pressure sensors, and electro-hydraulic servo valves (EHSV).

The proposed amplifier consists of a closed loop system that removes the non-linearity of the open loop system and allows providing a more stable output. Also, it compensates for changes in the power supply and allows to drive multiple loads with multiple values. The open loop design consists of two sub-blocks, high side gate driver and low side gate driver with a novel self-adjusting high voltage deadtime generator that generates the deadtime required to prevent short circuit current in the output stage. Each gate driver consists of two high-voltage level up shifter to convert the low-voltage level to the required voltage levels, two buffer chains, two level down shifters for the feedback circuit of the self-adjusting deadtime generator, and two large power MOSFETs in the output stage.

Polytechnique Montréal
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High Voltage Level Up and Level Down Shifter for High Voltage Gate Drivers in Aerospace Applications

Applications include: Aerospace

This design includes a Level up Shifter, which is a key circuit used for voltage conversion between different voltage domains. It consists of low voltage power transistors and high voltage power transistors to handle the conversion between the low voltage domain and the high voltage domain. In addition, we propose a Level down shifter to convert the high voltage input signal to a low voltage input signal, it has similar high voltage and low voltage transistors however the PMOS and NMOS transistors are interchanged, and the power supply levels are inverted. Both shifters are used as part of high voltage gate drivers intended for high voltage power converters and power amplifiers that require high voltage converters with fast speed and power supply slew rate immunity.

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Technology: 350-nanometer CMOS

AMS 0.35µm CMOS (OPTO)

A Multi-tune Deadtime Generator for Optimal-Power Conversion

Applications include: Aerospace

This design aims to implement a reconfigurable dead-time circuit intended for optimum power-converters' operation. This circuit is essential in the transmitter part of the BD429 data bus interface. The presented dead-time circuit receives a pulse signal with an amplitude of 3.3V and generates two non-overlapping signals with variable dead-time between them. The proposed circuit includes a programmable delay element to produce a wide range of dead-time delays for different power conversion's applications with various loads and input voltages. With this programmability feature, we could determine the required dead-time delay that allows optimum operation of a power converter, and hence maximizing the conversion efficiency.

Université Laval
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A Time-based Digitally Tuned Sensor Interface Intended for Avionic Applications

Applications include: Aerospace

This project aims to implement a versatile Systems-on-Chip integrated sensor interface for avionic applications. Since traditional analog interfaces' performance is degraded in the advanced CMOS technologies, time-based interfaces have become more popular recently thanks to their highly digital implementation which offers a small area, a high energy efficiency, and good scalability. In this design, we present a novel architecture of a time-based sensor interface. It has several digital blocks such as time domain comparators, and phase detectors.
In addition, a pulse generator circuit based on the CMOS thyristor-based delay element is used to detect fault states in the proposed sensor interface. The proposed delay cell employs a digitally controlled current source in which discrete voltage allows manipulation of delays through digital means. Thus, delay changes with respect to input vector. This design shows less sensitivity to supply and temperature variations, while maintaining low-power consumption. The pulse generator structure can provide a stable and constant pulse with width in range of nano to micro-second regardless to its input performance.

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Boost Convertor

Applications include: Natural Resources/Energy

The boost convertor is designed to boost a 1.8 V voltage to several desired voltage levels ranging from 3.3V to 4.12V. It includes a main circuit, a control circuit of boost convertor, a MPPT block and a primary battery control circuit which is used to detect and control the operation mode of the boost convertor. There are three different operation modes based on the voltage level: normal mode, overvoltage mode, and primary battery mode.

University of Alberta
Designer: Shuren Wang | shuren@ualberta.ca
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Cold Start System
Applications include: Natural Resources/Energy

The cold start system is designed for an RF energy harvesting system. It is able to boost a voltage at low level down to 300 mV to 1.8V, which is the minimum voltage level required to support an energy harvesting system. It mainly includes a current starved oscillator and a new designed charge pump.

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Energy Management IC
Applications include: Natural Resources/Energy

The chip is designed for RF energy harvesting and management. It is capable of converting the RF energy harvested from the environment into usable power for other applications, with ultra low start up voltage and high efficiency. For example, it can be stored in general storage element like super capacitors or work as stable power source for other applications.

University of Alberta
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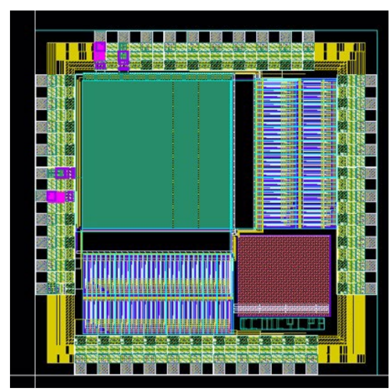
Professor: Jie Chen | jc65@ualberta.ca

Loop Pixel
Applications include: Aerospace, Automotive, Defence (Safety, Security), Entertainment, Health/Biomedical, ICT

Loop Pixel Topology



University of Calgary
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Professor: Orly Yadid-Pecht | orly.yadid-pecht@ucalgary.ca

Power Convertor
Applications include: Natural Resources/Energy

The power convertor works in an energy management system, it is designed to convert the voltage of specific energy storage element to two other desired voltage levels, and it can provide sufficient driving currents for the loads.

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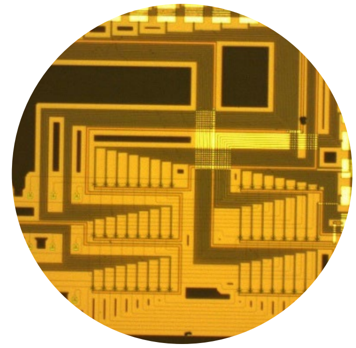
PHOTONICS & OPTOELECTRONICS



CMC delivers a program that includes fabrication access to silicon photonics platforms for chip-level monolithic integration, methodologies for scalable integrated photonics design, and training in the design, fabrication, and testing of photonic integrated circuits. CMC enables photonics integration with a strong emphasis on putting more photonic functionality onto each chip, integrating photonics with other technologies including microelectronics, and using both hybrid and monolithic approaches.

Spotlight on photonics: www.CMC.ca/Photonics

Technology: 45-nanometer CMOS-Photonics

GF 45SPCLO

Integrated Circuit Architectures for Photonic Applications

Applications include: ICT

The design includes two main parts. The first part aims to use photonic architectures to implement computing systems including neural networks supported by electronic blocks. The second part focuses on implementing electronic circuits to improve the performance of silicon photonic transceivers.

University Of Toronto
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Technology: 220-nanometer Silicon-on-Insulator

ANT E-Beam 220nm NanoSOI

A Novel Architecture for Practical Programming of Optical Processors

Applications include: ICT (photonics for Artificial Intelligence (AI) and Machine Learning ML))

Interferometric based programmable optical processors are promising structures for fast and low power optical computation. Particularly, they can be used to efficiently perform the vector-matrix multiplication task of optical neural networks (ONNs). This is due in part to the inherent parallelism present in optics and to the low-energy cost of computation for various linear optical transformations. Employing power efficient computational accelerators in silicon photonic (SiPh) platforms will allow the construction of larger ONNs while maintaining low energy consumption, thus meeting the computational demands of future ML applications. However, calibration and programming the optical processors have remained challenging due to several reasons including fabrication variations, phase errors in interferometers, and complexities in measurement of optical phase. The proposed design leverages our previous programmable optical processors demonstrated in SiPh. The main contribution of the proposed design is the low-cost, fast, and practical training procedure. In conventional programmable optical processors, one needs either an Optical Vector Analyzer (LUNA OVA 5013 or similar) or a coherent detector to measure the optical phase of phase shifters and calibrate/program the processors. Use of coherent detectors considerably increases the cost and complexity of the calibration/programming. In this design, we have overcome this challenge by introducing a new building block that enables optical phase measurement without coherent detection.

McGill University
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Professor: Odile Liboiron-Ladouceur | odile.liboiron-ladouceur@mcgill.ca

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Demonstration of signal modulation enabled by Silicon Photonics based programmable absorbers

Applications include: ICT

SiP based photonic computing provides a promising solution to innovatively perform computations at speeds faster than comparable electronic chips while consuming less power. Low-speed intensity modulation using programmable absorber materials is a novel method to enable photonic computing. The goal of this project is to investigate test structures compatible with programmable absorber material. We will study different post-fabrication integration schemes with programmable absorber materials. More specifically, the post processing, which will be accomplished by our industrial partner (https://www.3e8.co/), will fulfill our strong interest in studying and optimizing non-trivial driving signals to program the absorber and further control the attenuation being imposed on the input optical signal. The conclusion of this investigation will pave the way for system integration of programmable absorbers toward realizing photonic multiplication.

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Grating Receiver Array for LiDAR Applications on a Silicon Photonics Platform
Applications include: Automotive

Light detection and ranging (LiDAR) technology has advanced significantly in recent years due to its potential in publicizing autonomous vehicles. Silicon photonics has already been established for various optical communications and sensing applications, thus making it a viable candidate for LiDAR applications, including autonomous vehicles. Thus far, optical phased arrays have been shown to successfully transmit and receive light between the on-chip platform and the free space environment in need of detection. This design aims to test and characterize the performance of grating receiver antennas, the fundamental building blocks of optical phased arrays, and will be the first of many towards developing cutting edge optical phased arrays on a silicon photonics platform for LiDAR applications.

McMaster University
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Professor: Jonathan Bradley | jbradley@mcmaster.ca

High-sensitive Biosensor
Applications include: Health/Biomedical

High-sensitive biosensor can be achieved by using subwavelength grating slot waveguide as sensing area, and monitoring and controlling wavelength of laser in a high accuracy.

University of British Columbia
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Professor: Lukas Chrostowski | lukasc@ece.ubc.ca

Integrated Heralded Single Photon Sources in Silicon
Applications include: ICT (quantum communications and computing)

In this chip we would like to integrate a laser with a micro-ring resonator (MRR) photon-pair source on a silicon chip. This MRR is followed by a contra-directional pump reject filter and a coupler of MRR based wavelength demultiplexers (WDMs). The pump reject filter will eliminate the laser pump after the ring and the WDMs will separate the photon-pairs to exit from two different waveguides. Detecting these photons using single photon detectors and working with the photons of the other pairs makes this circuit a heralded single photon source. This has many applications in photonic quantum computing and quantum key distribution and random number generation.

University of British Columbia
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Professor: Lukas Chrostowski | lukasc@ece.ubc.ca

Laser Integrated with Phase Change Materials
Applications include: Defence (Safety, Security), ICT

Neuromorphic circuits model artificial neural networks(ANNs) following analog representations. They can solve certain problems efficiently and become more powerful with size. A significant restriction on the size of a neuromorphic system is the optical and electrical I/O. Integration of lasers on chip is key to decreasing the optical input footprint. Phase change materials are capable of storing information in a non-volatile manner and eliminate the need for electrical I/O for configuring the neuromorphic system. The goal is to characterize the integration of lasers onto a silicon photonics platform and their interaction with phase change materials. These two technologies are key for expanding the computing capabilities of neuromorphic systems.

Queen’s University
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On-chip Electron-Photon Coupling
Applications include: ICT

Our goal is to demonstrate and publish an on-chip device design using the Silicon-on-Insulator platform that supports strong photon-electron coupling. For this design, light will couple into a SiP chip with no upper cladding so that a free electron can interact with the evanescent field of a waveguide mode. The design is composed of various passive Si photonic components such as grating couplers, splitters, Bragg reflectors and slot waveguides.

McGill University
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Professor: David Plant | david.plant@mcgill.ca

On-Chip Silicon Photonics Antenna
Applications include: ICT

The on-chip unification of photonics and RF wireless components is a profound step in the continuous effort of system designers to extend the advantages of silicon integration to higher frequencies. Overcoming this hurdle will pave the way for many interesting avenues to photonics researchers. An antenna integrated into a silicon photonics (SiPh) chip will reduce electrical power loss by averting the frequency dependent off-chip parasitic interconnects between the photodetector and the antenna. In addition, the on-chip antenna will eliminate the need for a matching network to transform the system impedance to 50 O. Therefore, antenna impedance becomes one of the design parameters that further provides design flexibility

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Professor: Odile Liboiron-Ladouceur: odile.liboiron-ladouceur@mcgill.ca

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Photonic Phase-change Memory
Applications include: ICT

Grating couplers to couple fiber mode into silicon waveguides, Wavelength filtering using MRR into the various PCM cells. The objective is to be able to access non-volatile memory cells via light and WDM in order to do MAC operations with the encoded values.

Polytechnique Montreal
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Professor: Yves-Alain Peter | yves-alain.peter@polymtl.ca

Silicon Metasurface for Biosensing
Applications include: Health / Biomedical

The project aims to explore the potential of Fano resonance based optical biosensors in an all-dielectric Si platform. In this regard, we designed and plan to fabricate densely packed nanostructures (2D metasurface) which resonates in the optical communication regime, making the sensor lossless. The resonance spectrum has numerous electric and magnetic multipole signatures. The dense nature of the architecture helps couple these multipoles giving rise to a strong Fano resonance, which demonstrates a very sharp reflection peak. The characteristic peak shifts in response to a change in the surrounding medium refractive index. Our goal is to leverage such sharp features to develop highly sensitive lossless all-dielectric optical biosensors.

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Professor: Stewart Aitchison: stewart.aitchison@utoronto.ca

Silicon Photonics Device Optimization and Inverse Designs
Applications include: ICT (signal processing, communications, computing)

The designs will include an array of devices for experimental verification of a curve-loss of photonic ring devices. The structures fabricated will be used to determine the device density and feature size limitations of the devices. Devices made through designer-assisted inverse design will also be included. These inverse designs aim to improve PCELLs that are part of the SiEPIC process design kits (PDKs) and successful improvements will be updated by into the PDK.

University of British Columbia
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Professor: Lukas Chrostowski | lukasc@ece.ubc.ca

Subwavelength Grating-based Waveguide Bragg Grating Devices

Applications include: ICT

Subwavelength grating (SWG) waveguides, with lower propagation losses and flexibility in tailoring effective indices, have attracted significant attention to enhance the performance of conventional passive devices, e.g., couplers and filters. Recently, SWG waveguides have been widely applied in the design of waveguide Bragg gratings (WBGs). We have demonstrated chirped SWG WBGs to provide optical delays over large bandwidths as well as wideband phase-shifted SWG WBGs for ultrabroadband signal processing. Here, we will expand the SWG waveguide toolbox to allow for the development of more complex photonic integrated circuits with increased and unique functionalities and greater robustness. Specifically, we will demonstrate (1) multi-channel filters, e.g., for WDM applications, based on sampling a SWG WBG structure and (2) random Bragg structures based on random sampling of SWG WBGs and/or random arrangements of the Bragg scattering points.

The following devices will be directly used from the SiEPIC process design kits (PDKs) on a planned 9 mm x 9 mm sized chip: (1) Optical I/O - TE Vertical Grating Couplers (VGC) 8-degree Oxide from ANT PDK and (2) Y branch - from SiEPIC_Ebeam_Library – v0.3.36. (Note that there is no need for post-treatment or removing the top oxide.)

McGill University
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Professor: Lawrence Chen | lawrence.chen@mcgill.ca

Thermally Modulated Bragg Filters

Applications include: (ICT (networking and information technology)

A series of narrowband SWG Bragg filters are combined with a periodic heater layout. The periodicity of the heater profile leads to an index modulation that can dynamically induce sidelobes in the Bragg filter output spectrum.

Carleton University
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Professor: Winne Ye | winnie_ye@carleton.ca

Technology: Silicon Nitride (SiN)

ANT SiN

Optical Frequency Comb in Large Normal Dispersive Silicon Nitride Micro Resonator Using Four Wave Mixing

Applications include: Health / Biomedical, ICT

Optical frequency comb (OFC) is an interesting and demanding research topic for its vast application in different fields such as optical communication, biosensing, meteorology, spectroscopy, etc. It provides large bandwidth, high speed and high sensitivity in terms of absorption sample. Several methods have already been established to generate optical comb in the recent decade, such as cascading modulators, highly nonlinear fiber loop, mode locked laser etc. Integrated photonic chip based optical comb is making it more compatible and efficient device due to low power consumption instead of high power in conventional fiber combs. Silicon nitride (SiN) is one of the best nonlinear mediums due to its high index contrast, and low temperature sensitivity for OFC generation. The generation of OFC silicon nitride based micro-resonator is efficient due to its high-Q factor and high confinement of light into the ring cavity. Kerr nonlinear effect such as four wave mixing (FWM) is one of the most promising approaches to generate OFC in micro-resonator in large dispersion region. The proposed design for OFC generation based on the thin silicon nitride micro-resonator is a new approach to reduce large normal dispersion and increase FWM conversion efficiency to generate broadband spectrum lines.

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Technology: Silicon Photonics – Active & Passive Silicon on Insulator

AMF Silicon Photonics

Active Opto-mechanical Phase Tuner

Applications include: Aerospace, Defence (Safety, Security), ICT

This project aims to develop a suspended active optomechanical phase tuner on the silicon photonics platform. The design will demonstrate a novel, compact geometry using electro-static actuation. The proposed design aims to reduce power requirements for active phase control of an optical signal relative to the thermo-optic technique. Post-processing of the AMF fabricated chips will be conducted at Western Nanofab to remove the top and buried cladding surrounding the silicon device layer.

Western University
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Coherent Summation Photonic Digital to Analog Converter
Applications include: ICT

The growing bandwidth requirements of data center communications has created an increasing need to increase the number of bits per symbol and go beyond PAM-4 communication protocol especially for short-reach data center interconnects (DCI). Silicon based coherent summation photonic digital to analog converters (CSPDAC) are attractive solutions to create PAM-M signals with M larger than 4. In these architectures, a single wavelength is used for all the input bits which reduces transmitter complexity. It allows further increase of the transmitter bandwidth via wavelength division multiplexing.

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DAC-less ring Based High-speed PAM-4 Modulator
Applications include: ICT

The ring-based PAM-4 modulator consists of a ring and MZI (Mach Zehnder Interferometer) acting as the coupler. The device benefits from the compactness and speed of the ring and the wide bandwidth of MZI. By introducing the ring, the device is made DAC-less (Digital to Analog Convertor) The device proposed would work on the principle of intercoupled ring modulator and the heater in the design is used to tune the modulator and the segmented phase shifters to modulate signal. The device will also consist of a 50-ohm terminator for impedance matching and an inductance coil to prevent any AC signal escaping into the instrument. This modulator will be designed for speed of 50Gbps relative to its predecessor which was 25 Gbps. This device is useful for short reach interconnects between data centres and to improve the optical communication.

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Dense Wavelength Division Multiplexing (DWDM) Silicon Photonic Link
Applications include: ICT

The objective of this project is to develop a Tb/s dense wavelength division multiplexing (DWDM) transceiver for short-reach optical interconnects. The proposed design consists of a transmitter (TX) based on cascaded microring modulators (MRMs) and a receiver (RX) block using an integrated arrayed waveguide grating. Variations of critical building blocks will also be implemented to optimize the component design and link configuration.

Laval University
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High Speed Devices and Integration to Enable Online Learning for Optical Computing
Applications include: ICT (optical computing, high-speed communication, Deep Learning)

We will demonstrate novel fabrication cavities compatible with Photonic Wire Bonding. We will use these cavities to integrate off-shelf semiconductor optical amplifiers. We will also demonstrate novel high-speed devices, such as modulators and detector, which will be postprocessed at our institution.

University of British Columbia
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Professor: Bhavin Shastri: bhavin.shastri@queensu.ca

High Speed Silicon Modulators
Applications include: Other (Optical Fiber Communication)

1. High Speed Silicon Mach-Zhender Modulator (MZM) Design
2. Ring Modulator Circuitry: Phase Modulator using Rings

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High-Q Silicon Photonic Cavity Structures for On-chip Lasers
Applications include: Automotive, Health/biomedical, ICT

Light emission is a primary challenge in silicon photonics. With this design we aim to build on recent results showing optical gain on the AMF silicon photonics platform and develop new light sources for silicon photonics. We have developed an economic and scalable approach to light sources on silicon using doped and undoped thin films deposited via post-processing steps on the silicon photonic chip. The designs will focus on structures that can potentially be used for integrated laser cavities and nonlinear optical Kerr comb sources on a silicon platform using AMF technology, by post processing deposition of rare earth doped and undoped tellurium oxide. These new light sources will be used in applications including microwave photonics, LIDAR, artificial intelligence, sensing and communications.

McMaster University
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Integrated Circular Phased Array
Applications include: ICT (light detection & ranging), Automotive/Transportation (autonomous vehicle)

Implementation of an SOI-based on-chip integrated circular phased array which provides a large steering range and high angular resolution. One key application of the phased array circuit is an emitter of an integrated photonic lidar for autonomous vehicles.

Carleton University
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Integrated Microwave Photonics-based RF Transmitter

Applications include: ICT

Monolithic integration of RF antennas onto a silicon based integrated microwave photonics (IMWP) chip eliminates parasitic interconnects, thereby reducing system loss for high data rate communication. In addition, the on-chip antenna will eliminate the need for a matching network to transform the system impedance to 50 O. Therefore, antenna impedance becomes one of the design parameters that further provides design flexibility. Synthesizing highly spatial beam with high gain is possible as small wavelength at millimeter wave (mmW) frequencies allows for compact implementation of more than one antenna on the desired chip area (3 × 8 mm2). For implementing such antenna arrays structures on chip, integrated beamforming/beam steering network is required, which can be designed using either electronic or photonics approach. Electronic integrated circuit approach for mmW beamforming typically suffers from bandwidth limitations, high insertion loss, and limited tunability. To alleviate these electronic bottlenecks, integrated microwave photonic (IMWP)(a discipline that combines RF engineering and optoelectronics) based beamforming is proposed that allows for ultra-wide instantaneous bandwidth, delay tunability, EMI immunity, high frequency operation, and capability to scale for large arrays without beam squint problem. Thus, Monolithic implementation of photonic front-end combining optical true time delay (OTTD) beamforming, photodetector, and antenna array is one of the ultimate challenges for IMWP designers and motivation of this proposal.

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Intelligent Signal Processing with Silicon Photonics

Applications include: ICT

Many applications nowadays need hardware to deliver gigahertz bandwidth and low-latency computing. These applications have tight requirements for high throughput, low energy, and low latency. Therefore, operating the applications in real-time remains a major challenge. Photonics promises to tackle these challenges by developing radical new hardware platforms providing unrivaled capabilities for interconnects and communication that may overcome the bandwidth and interconnectivity trade-offs that electronics essentially suffers from. In this tapeout, we will design several novel systems for intelligent information processing, including (1) the hybridization of a photonic neuromorphic CNN processor with a digital electronic FPGA; (2) Optical communication channel equalization with recurrent photonic neural networks; (3) Photonic blind source separation for multimode optical interconnect.; (4) Fast online learning assisted with FPGA. We will also improve the design of our previous chip based on the testing result and integrate the combination of improved designs onto a silicon photonic neural network onto this chip to be able to perform the first demonstration of a practical large-scale photonic neural network.

Queen's University
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Integrated Silicon Photonic Transceivers and WDM Filters for Quantum Key Distribution (QKD)

Applications include: ICT (optical communications and data communications, quantum secure communications)

We propose to design, implement, and characterize a fully integrated silicon photonic Quantum Key Distribution (QKD) transceiver for secure communication applications. This is important because it is the SiP platform which offers the promise of low-cost mass production and the co-integration of control electronics that will be required to optimize real system performance. Recently a group in Singapore demonstrated a fully integrated continuous variable QKD system on chip. Our focus in this project is to first design and characterize the individual components of the QKD transceiver such as single photon detectors, single photon sources and WDM optical filters, and consequently use the developed components to build a fully integrated QKD transceiver with discrete variable encoding which can achieve high rates of secure key bits for longer QKD links. The design consists of two chips, one is dedicated to the receiver that may include single photon detectors and the other will include the QKD transmitter which may include heralded single photon sources. These heralded single photon sources require two filter stages for pump rejection and wavelength division multiplexing. We already have a chip that has a differential phase shift QKD receiver circuit and need an additional transmitter chip for the same protocol. Also, we would like to use photonic wirebonding to couple light in and out of the chip for better performance than the available GCs.

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Integrated Super-channel Transmitter for 2.4 Tbits/s Optical Transmission

Applications include: ICT (telecom)

The proposed design is an integrated super-channel transmitter consisting of an on-chip optical frequency comb and an array of dual-polarization IQ-modulators integrated on a single chip. Flexible frequency comb lines will be generated using cascaded modulators. Our proposed device will achieve a high-speed coherent optical transmission beyond 2 Tbits/s. To the best of our knowledge, such a high-rate all-silicon optical transmitter has not been reported yet. First challenge lies in the relatively low bandwidth of silicon modulators and the modulation loss at high frequencies. We will address this issue using an inductive peaking technique to drastically increase the bandwidth. Second challenge is the high number of DC and RF inputs. We develop an optical and RF packaging solution for test in system.

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Professor: Professor: Wei Shi | wei.shi@gel.ulaval.ca

Microring Modulators (MRMs) for Coherent Transmission

Applications include: ICT

The proposed design is a chirp-free IQ modulator using microring modulator (MRM) integrated with monitoring circuits which has never been demonstrated before. Our proposed device will achieve a high-speed coherent optical transmission with low power consumption, which is a prominent candidate for short-reach applications such as datacenter interconnects. Demonstration of high-order QAM modulation formats using MRMs will pave the way for the penetration of coherent transmission into short reach domain. To the best of our knowledge, experimental demonstration beyond QPSK using MRMs has not been reported yet in the literature. This is mainly due to two challenges. First, MRMs suffer from a limited bandwidth, which will be enhanced in our design using higher doping levels with an optimized junction design to simultaneously increase the optical bandwidth and modulation efficiency. The second challenge lies in the modulation chirp of MRMs, which is the residual modulation of phase while the intensity changes. We will address this issue by using the push-pull configuration. We will also explore segmented electrodes for higher-order modulation without using an electrical digital to analogue converter for low-power coherent transmission at both 1310 nm and 1550 nm.

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On-chip Hybrid Light Sources

Applications include: Automotive, Health/Biomedical, ICT

Light emission is a primary challenge in silicon photonics. With this design we aim to build on recent results showing optical gain on the AMF silicon photonics platform and develop a new light source for silicon photonics. We have developed an economic and scalable approach to light sources on silicon using doped and undoped thin films deposited via post-processing steps on the silicon photonic chip. The designs will focus on structures that can potentially be used for amplifiers, integrated laser cavities and nonlinear optical Kerr comb sources on a silicon platform using AMF technology, by post processing deposition of rare earth doped and undoped tellurium oxide. These new light sources will be used in applications including microwave photonics, LIDAR, artificial intelligence, sensing and communications.

McMaster University
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On-chip MEMS Based Tunable Laser

Applications include: ICT

The project targets the realization of a tunable laser, in a low-cost and integrated version, with wide tunability. It will leverage and enhance optical networks, particularly for datacenters, by circumventing some limitations of tunable diode lasers. To achieve this, an efficient (mono-order) diffraction grating is designed to provide a wavelength selection and is associated with a MEMS to provide the mechanical tunability by displacing an input waveguide that changes the incidence angle of light on the diffraction grating. This forms an on-chip external cavity to be used as part of the tunable diode laser.

Specifically, here, we are designing an integrated multi-channel optical filter for an external cavity diode laser. This filter could simultaneously filter several bandwidths according to the filter channel spacing. It is also possible to control the filter output wavelength by mechanically deforming the waveguides with a micro-electro-mechanical device by post-processing to release the slab waveguide. Apart from tunable laser source application the presented on-chip reconfigurable multi channel optical filter has a wealth of applications in multiple optical signal processing for programmable optical networks, such as dense wavelength division multiplexing (DWDM) systems and switching. Furthermore, this project could have potential applications in other fields like measurements, particularly in the manufacture of frequency combs.

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Optical Frequency Comb Generation Based on Microwave Resonator for WDM System

Applications include: ICT

The proposed design is an integrated optical frequency comb (OFC) generator for wavelength division multiplexing (WDM) systems. The design uses a ring resonator in Radio frequency (RF) domain that provides a stable RF source for a silicon phase shifter. It has been theoretically and experimentally proved that by applying a high-power RF signal to an optical modulator, one can have comb lines with performance dependant on the power of RF signal and the Vp of the modulator. The first challenge for having a large number of comb lines is the difficulty of having a high-power RF signal at high frequencies. Providing High power RF amplifiers at high frequencies is expensive and a burden for packaging and integrated systems. This novel design can drastically reduce the power required by RF amplifiers for high-frequency on-chip comb generation.

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Pattern Recognition and High-Performance Computing Enabled by On-chip Matrix Multiplications

Applications include: Defence (Safety, Security), ICT

We investigate silicon photonic neuromorphic circuits for pattern recognition. Neuromorphic circuits model artificial neural networks (ANNs) following analog representations. Such implementations allow for the design of specialized hardware that will solve specific problems efficiently. Most significant advances in artificial intelligence (AI) have been achieved using a perceptron as an artificial model of a neuron. Perceptrons encompass the most general functions of biological neurons, which can be summarized as weighted-additions nonlinearly transformed by activation functions. Weighted-additions also represent the core operation for dot products between matrices. Neuromorphic photonics exploits optical device physics to perform all matrix multiplications behind perceptron-based computing, and optical interconnects for distributed, parallel, and analog processing.

This research is at the interdisciplinary interface of nanophotonics (optical physics) and unconventional computing that could open new frontiers in artificial intelligence (AI). Combined with our prior knowledge and work on photonic neuromorphic computing, such architectures could enable applications for ultrafast and online learning and inference.

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Silicon Based Integrated Microwave Photonic Beamformer

Applications include: ICT

Recently, there has been a strong impetus towards developing millimeter-wave (mmW) wireless communication systems driven by the need for spectrum availability, increased bandwidth capability, and high data rates of near future technologies like 5G, autonomous vehicles, IoT's and short-reach high-speed communication. Integrated beamforming/beam steering using phased array is an extremely attractive solution for practical implementation of such systems. Electronic integrated circuit approach for mmW beamforming typically suffers from bandwidth limitations, high insertion loss, and limited tunability. To alleviate these electronic bottlenecks, integrated microwave photonic (IMWP)(a discipline that combines RF engineering and optoelectronics) based beamforming is proposed that allows for ultra-wide instantaneous bandwidth, delay tunability, EMI immunity, high frequency operation, and capability to scale for large arrays without beam squint problem. IMWP shifts the signal generation, processing, distribution, and remote antenna tasks from radio domain to photonic domain, thereby accessing abundant bandwidth and ultra-low attenuation. Moreover, the loss is almost frequency independent. Further, to reduce complexity and interconnection loss, antenna units can be further integrated with IMWP chip. In this project, a silicon-based IMWP beamformer with multipath switchable delay lines is proposed on photonic integrated chip. Before this, we had successfully demonstrated the feasibility of RF on-chip antenna on PIC. The intended application of this proposed design is short reach high frequency wireless communication between two SiPh and last mile access solutions.

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Silicon Photonic Circuits for Optical Communication
Applications include: ICT

We proposed several designs for integrated silicon photonic (SiPh) circuits, targeting various components in an optical communication system. The chip basically contains three projects. The first project focuses on the transmitter side. Recently we have reported several SiPh travelling wave Mach-Zehnder modulator (TWMZMs) enabling up to 200 Gb/s transmission, while the objectives of the proposed designs in this tape-out are to explore the potential of lumped modulators with inductive peaking effect. As for the second work, we propose a novel design for SiPh carrier-assisted self-coherent receivers. We utilize previously demonstrated on-chip dispersion compensator to form a cost-effective receiver that only requires 2 photodetectors per polarization, which can recover double sideband (DSB) complex signals. The third activity is dedicated to an integrated switchable radio-frequency (RF) photonic frequency converter that can operate up to 40 GHz. The system will be integrated on a single silicon chip based on our previously fabricated and tested TWMZMs and photodiodes.

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Silicon Photonic Circuits for the Study of Parity-Time Symmetry and Anti Parity-Time Symmetry
Applications include: ICT

The objectives of the project are to realize 1) a multimode interference (MMI)-based parity-time (PT) symmetric optical filter and 2) a high-sensitivity optical sensor based on anti-PT symmetry, with each on a silicon photonic chip. The MMI-based PT-symmetric optical filter consists of a 3×3 MMI coupler with the upper and lower branches having two identical coupled micro-ring resonators (MRRs). The MMI coupler is optimized for transverse-magnetic (TM) mode at the upper output port and transverse-electric (TE) mode at the lower output port. When the balanced gain/loss factor induced by the polarization of the input light exceeds the coupling coefficient, PT symmetry is broken, and an optical filter with an ultra-narrow bandwidth is achieved. The anti-PT symmetric optical sensor is implemented by two MRRs sharing a pass-through bus waveguide. The distance between a MRR and the bus waveguide is precisely controlled to make the MRRs are coupled to the bus waveguide, but no direct coupling between the two MRRs. A micro-heater is placed on top of one MRR to emulate the environmental temperature change. The measurement of the temperature change can be quantified by the frequency detuning when anti-PT symmetry breaking.

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Silicon Photonics Based RF on-chip Antennas Integration with Photodetector and Si-epi Ge Photodetectors at 1550 nm

Applications include: ICT

Project 1: The on-chip unification of photonics and RF wireless components is a profound step in the continuous effort of system designers to extend the advantages of silicon integration to higher frequencies. An antenna integrated into a silicon photonics (SiPh) chip will reduce electrical power loss by averting the frequency dependent off-chip parasitic interconnects between the photodetector and the antenna. In addition, the on-chip antenna will eliminate the need for a matching network to transform the system impedance to 50 O. Therefore, antenna impedance becomes one of the design parameters that further provides design flexibility. In this project, a meander monopole antenna working at 22GHz integrated with Ge photodetector is proposed on the silicon based photonic integrated circuit (PIC). Before this, we had successfully demonstrated the feasibility of RF on-chip antenna on PIC working at 15 GHz. The intended application of this proposed design is short reach high frequency wireless communication between two SiPh.

Project 2: The photodetector (PD) is regarded as the interface between the optical circuit and the electrical circuit. In short-reach applications, the receiver noise is the dominant noise source. A PD with larger responsivity improves the receiver sensitivity and further reduces the required electrical gain of the downstream circuits. In this project, several configurations of Ge photodetectors with vertical cavity have been designed. Without contributing to the devices' parasitic capacitance, an attempt of increasing the responsivity was made by the inclusion of the Bragg grating reflector at the end of the Si-slab. Thus, a fraction of the light will be sent back to the absorption region which is not absorbed in its first pass. Moreover, to further reduce the optical loss, multi-finger like contacts have been used instead of off-centered continuous contacts. It will enhance the responsivity at a cost of higher resistance.

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Silicon Photonics Enabling True Time Delay for Optical Beam Forming for RF Phased Arrays

Applications include: ICT

This design will address the need for true time delay in Satellite Communications (SatCom). Specifically, we wish to demonstrate tunable time delay in an integrated circuit using micro-ring resonator (MRR) and Mach-Zehnder (M-Z) filters. We will also integrate high-speed M-Z modulators for RF modulation and photodiodes for RF conversion. We will employ recently developed (by us) trimming techniques to significantly reduce the complexity of closed-loop control and power consumption (relative to previous work previously reported). This work involves three McMaster University groups in collaboration with Canadian company MDA (previously known as MacDonald, Dettwiler and Associates) of Montreal. The work will generate new knowledge and has a route to technology transfer for the betterment of Canadian industry.

McMaster University
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Silicon RF-Photonic Tunable Frequency Downconverter

Applications include: ICT

Driven by the inherent advantages of Radio-frequency (RF) photonics, our design aims to demonstrate a silicon photonic (SiPh) optical coherent receiver based tunable RF frequency downconverter that can operate up to 40 GHz; thereby, covering most of the practical RF spectrum. A similar system with a limited operational bandwidth of 18 GHz has been reported by our industrial partner based on lithium niobate Mach-Zehnder modulators and discrete optical components. In this project, we are redesigning the system to be fully integrated (excluding the DFB laser) on a silicon photonic chip that includes our high bandwidth (40 GHz) traveling-wave Mach-Zehnder modulator (TW-MZM) design. The chip will be fully packaged by our industrial partner to reduce the losses and for reliable testing. The proposed design is a step towards an all on-chip RF photonic system, which provides a better performance at a smaller footprint, lower cost, and reduced power consumption.

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Topological Microring Photonic Devices

Applications include: ICT

The project aims to experimentally demonstrate topological photonic insulator behaviours in circular arrays of microring resonators. Topological photonics is a new class of photonic devices and structures that have been shown to exhibit exotic behaviours, such as robustness to fabrication imperfections, strongly localized modes and diffraction-less propagation that could be exploited to engineering fabrication-tolerant integrated optics devices. In our project we propose a new topological photonic lattice based on a circular array of microring resonators. By periodically varying the coupling coefficients and resonant frequencies of the microring resonators, we have shown theoretically that the structure can exhibit topological behaviours. The devices and structures submitted to the 2001PH AMF Silicon Photonics fabrication process will be used to experimentally verify the predicted topological properties. While NnN doped silicon was used for thermo-optic tuning of the circular array of microrings, we also implement thermo-optic heaters for silicon photonic devices using embedded pin doped junctions in the silicon waveguide cores. These in-line heaters are expected to yield higher thermal tuning efficiencies, faster tuning speeds, and lower thermal crosstalk than conventional metal heaters fabricated on top of silicon waveguides.

University of Alberta
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WDM in Silicon Photonics for Satellite Communications

Applications include: ICT

This design will address the need for true time delay in Satellite Communications (SatCom). Specifically, we wish to demonstrate tunable time delay in an integrated circuit using micro-ring resonator (MRR) and Mach-Zehnder (M-Z) filters. We will also integrate high-speed M-Z modulators for RF modulation and photodiodes for RF conversion. In addition, we will integrate wavelength division multiplexing to greatly increase the potential for information transfer. This work involves three McMaster University groups in collaboration with Canadian company MacDonald Detwiler Associates (MDA) of Montreal. The work will generate new knowledge and has a route to technology transfer for the betterment of Canadian industry.

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Technology: Silicon Photonics Training – Active Silicon on Insulator

Examples of projects using Silicon Electronic-Photonic Integrated Circuits Fabrication (SiEPICfab) consortium.

Advanced Micro Foundry (AMF) SOI

- Active Beam Steering for Long Range Optical Sensing
  University of Laval | Designer: Daniel Robin | Professor: Wei Shi

- Active Silicon on Insulator
  Laval University | Designer: Xun Guan | Professor: Leslie Rusch

- Active Silicon on Insulator
  Université de Sherbrooke | Designer: Philippe Arsenault | Professor: Jean-François Pratte

- Active Silicon on Insulator
  University of British Columbia | Designer: Mohammed Al-Qadasi | Professor: Sudip Shekhar

- Active Silicon on Insulator
  University of British Columbia | Designer: Omid Esmaeeli | Professor: Sudip Shekhar

- Beamforming System
  McMaster University | Designer: Dylan Genuth-Okon | Professor: Andrew Knights

- Cryo-compatible Photonics for Neuromorphics
  Queen's University | Designer: Marcus Tamura | Professor: Bhavin Shastri

- Coupled Recurrent Neural Networks
  Queen's University | Designer: Ahmed Khaled | Professor: Bhavin Shastri

- DWDM Filter Based on Arrayed Waveguide Grating in O-band
  University of Laval | Designer: Hui Wang | Professor: Wei Shi

- Energy-efficient Coherent Transmission and Detection for Short Reach Applications using Microring Modulators
  University of British Columbia | Designer: Sergey Anderson | Professor: Sudip Shekhar

- Grating Coupler Assisted Ring Mach-Zehnder Interferometer Modulator
  University of British Columbia | Designer: Tianye Wang | Professor: Nicolas Jaeger

- Microring Resonators with In-plane Micro-electromechanical Tuning
  University of British Columbia | Designer: Joshua Fabian | Professor: Lukas Chrostowski

- Microring Weight Bank with Extended FSR Microring Resonator
  University of British Columbia | Designer: Wenwen Zhang | Professor: Peyman Servati

- Mode Insensitive Phase Shifters for Multi-mode Switches
  McGill University | Designer: Joel Dodoo | Professor: Odile Liboiron-Ladouceur

- Neuromorphic Computing Based on Photonics Integrated Circuits
  Queen's University | Designer: Maryam Moridsadat | Professor: Bhavin Shastri

- Non-volatile Phase Change Material Based Photonics Neural Networks
  University of British Columbia | Designer: Daniel Julien-Neitzert | Professor: Lukas Chrostowski

- Novel Optical Phase Array
  University of Waterloo | Designer: Masih Bahrani | Professor: Lukas Chrostowski
- Optical Frequency Domain Reflectometry
  University of Toronto | Designer: Tianyuan Xue | Professor: Joyce Poon
- Optical Neuromorphic Computing
  Queen's University | Designer: Karanpreet Singh | Professor: Bhavin Shastri
- Optical Ring Resonators Embedded MZI Driven in Push-Pull Configuration
  McMaster University | Designer: Keru Chen | Professor: Andrew Knights
- Optically Controlled MZI and MRR
  McGill University | Designer: José Garcia Echeverria | Odile Liboiron-Ladouceur
- Polarization-insensitive Switch
  McGill University | Designer: Weijia Li | Professor: David Plant
- Quantum Optics on a Photonics Integrated Circuit
  University of Waterloo | Designer: Matteo Pennacchietti | Professor: Michael Reimer
- Quantum Optics on a Photonics Integrated Circuit
  University of Waterloo | Designer: Sasan V. Grayli | Professor: Michael Reimer
- Scalable Optical Switch Networks using Mach-Zehnder Interferometers
  University of British Columbia | Designer: Dias Azhigulov | Professor: Lukas Chrostowski
- Segmented Ring Modulator Design
  University of British Columbia | Designer: Sean Lam | Professor: Lukas Chrostowski
- Si/Ge Avalanche Photodetector
  McMaster University | Designer: Yuxuan Gao | Professor: Andrew Knights
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Parimal Edke | Professor: Johnathan Bradley
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Pooya Torab Ahmadi | Professor: Jonathan Bradley
- Silicon Photonic Ring Modulator-based Transceivers
  McGill University | Designer: Yu Wu | Professor: Odile Liboiron-Ladouceur
- SiN-Si Dual-layer Optical Phased Array
  McGill University | Designer: Yixiang Hu | Professor: David Plant
- Single Photon Entaglement Experiment with On-chip SFWM Source
  University of Toronto | Designer: Liang Shan | Professor: Amr Helmy
- Slow-light Mach-Zehnder Modulator
  University of Laval | Designer: David Turgeon | Professor: Wei Shi
- Topic Semi-on-Chip Linewidth Measurement
  University of British Columbia | Designer: Shangxuan Yu | Professor: Lukas Chrostowski
- Two-dimensional Optical Phased Arrays for Beam Steering
  University of Toronto | Designer: Tianyi Liu | Professor: Joyce Poon

Technology: Silicon Photonics Training – Passive Silicon on Insulator

Examples of projects using Silicon Electronic-Photonic Integrated Circuits Fabrication (SiEPICfab) consortium.

Advanced Micro Foundry (AMF) SOI

- Deep Trench Isolated Cascaded Contra-directional Couplers
  University of British Columbia | Designer: Alexander Tofini | Professor: Lukas Chrostowski
- FSR-free, MRR-based coupling Modulators
  University of British Columbia | Designer: Wangning Cai | Professor: Nicolas Jaeger
- Index-based Biomedical Ultrasund-sensing with High-Q Microcavities
  University of Toronto | Designer: Eric Zhu | Professor: Ofer Levi
- Inverse Design of Loss-uniform Arrayed Waveguide Grating (AWG)
  Université Laval | Designer: Xingguo Xiao | Professor: Wei Shi
- Modeling and Design of an in-plane MEMS Phase Shifter for Reconfigurable Photonic Circuits
  University of British Columbia | Designer: Joshua Fabian | Professor: Lukas Chrostowski
- Optical Filters Using a Contra-directional Coupler Assisted Microring Resonator Array
  University of British Columbia | Designer: Tianye Wang | Professor: Nicolas Jaeger
- Optical Ring Resonators Embedded MZI
  McMaster University | Designer: Keru Chen | Professor: Andy Knights
- Passive Silicon on Insulator
  University of British Columbia | Designer: Hany Abdelraheem | Professor: Sudip shekhar
- Passive Silicon on Insulator
  University of British Columbia | Designer: Sergey Anderson | Professor: Lukas Chrostowski
- Passive Silicon on Insulator
  University of British Columbia | Designer: Mohammadreza Sanadgol Nezami | Professor: Lukas Chrostowski
- Photonics-based Monitoring of CMOS Device Aging
  University of British Columbia | Designer: Ian Hill | Professor: Lukas Chrostowski
- Ring Resonator Sensor Based on Vernier Effect
  University of British Columbia | Designer: Wenwen Zhang | Professor: Lukas Chrostowski
- Semi On-Chip Linewidth Measurement Design
  University of British Columbia | Designer: Shangxuan Yu | Professor: Lukas Chrostowski
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Pooya Torab Ahmadi | Professor: Johnathan Bradley
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Parimal Edke | Professor: Johnathan Bradley
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Yuxuan (Michael) Gao | Professor: Andrew Knights

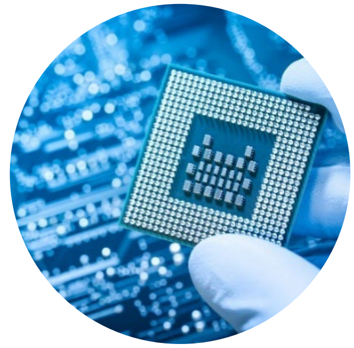
- Silicon Photonic Optical Amplifiers and Lasers
  University of British Columbia | Designer: Bruno Luis Segat Frare | Professor: Jonathan Bradley

- Strip Waveguide Loss Calculation and Layout
  University of Waterloo | Designer: Masih Bahrani | Lukas Chrostowski

- Thermal Stabilization of Microring in WDM Transeiver
  University of Toronto | Designer: Kelly Hunter | Professor: Ali Sheikholeslami

- Thermal Stabilization of Microring in WDM Transeiver
  University of Toronto | Designer: Mahdi Zabihpour | Professor: Ali Sheikholeslami

MEMS



Canada’s strong MEMS community includes two MEMS foundries (Teledyne DALSA (Bromont) and Teledyne Micralyne (Edmonton)), centres for pilot fabrication, packaging, system development (INO, C2MI, ACAMP), and several National Research Council (NRC) research centres. Additionally, 40 nanofabrication facilities at universities are used for research and proof-of concept demonstrations.

Spotlight on MEMS: www.CMC.ca/MEMS-nanofabrication-and-integration

Technology: PiezoMUMPs

MEMSCAP PiezoMUMPs

An Approach to Validate an Electro-thermally Actuated Power MEMS Switches Toward Sustaining High Breakdown Voltage and Power Handling

Applications include: Aerospace

The pathway towards a reliable electro-thermal actuated power MEMS switch using this technology requires a systematic approach to mitigate the effect of joule heating. Here, we implement a chevron (V-shaped) actuator design that incorporates isolation stage and heat sink beams in order to mitigate the elevated temperature across the floating contact.

École de technologie supérieure
Designer: Abdurrashid Hassan Shuaibu | abdurrashid-hassan.shuaibu.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

A Broadband Low-frequency Piezoelectric Energy Harvester

Applications include: Environment

The design is going to be used as a vibration-based piezoelectric energy harvester, which converts parasitic environmental vibration into the useful electric charges. The proposed structure has an optimized serpentine geometry with the integration of several proof masses at the links for reducing the operational frequency and improving energy conversion efficiency. Thanks to three degrees-of-freedom, the second and the third mode shapes can be located close to each other, providing a wide-band MEMS energy harvester. The model is validated by both analytical modeling and finite element simulation to satisfy expected results.

Memorial University
Designer: Hamidreza Ehsani-Chimeh | hehsanichime@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

An M-Shaped Wideband Piezoelectric Energy Harvester
Applications include: Environment

The design is going to be used as a vibration-based piezoelectric energy harvester, which converts parasitic environmental vibration into the useful electric charges. The proposed structure has an M-shaped geometry with the integration of three proof masses at the links for reducing the operational frequency and improving energy conversion efficiency. Thanks to three degrees-of-freedom, the second and the third mode shapes can be located close to each other, providing a wide-band MEMS energy harvester. The model is validated by both analytical modeling and finite element simulation to satisfy expected results.

Memorial University
Designer: Hamidreza Ehsani-Chimeh | hehsanichime@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

An Optimized Bistable Piezoelectric Energy Harvester
Applications include: Environment, ICT

The design is going to be used as a vibration-based piezoelectric energy harvester, which converts parasitic environmental vibration into the useful electric charges. The proposed structure has an optimized M-shaped geometry with the integration of two proof masses at the links for reducing the operational frequency and improving energy conversion efficiency. Thanks to three degrees-of-freedom, the second and the third mode shapes can be located close to each other, providing a wide-band MEMS energy harvester. The model is validated by both analytical modeling and finite element simulation to satisfy expected results.

Memorial University
Designer: Hamidreza Ehsani-Chimeh | hehsanichime@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

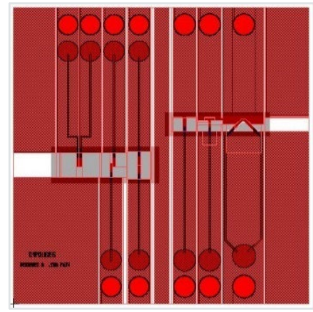
Design and Implementation a Fast and Accurate Micro-machined Ultrasound Flow Meter
Applications include: Aerospace, Automotive, Health/Biomedical

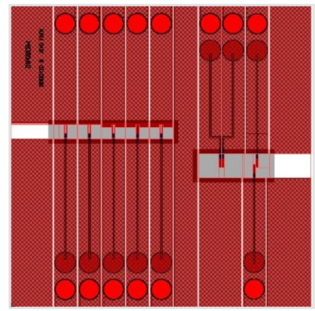
Working toward the design of new PMUTS (Piezoelectric Micromachined Ultrasonic Transducers). Designs has been prototyped using simulation and real-life measurements. These designs allow a higher displacement and a better control of the resonant frequency. The designs submitted in this area will allow real life measurements.

École de technologie supérieure
Designer: Amirhossein Moshrefi | amirhossein.moshrefi.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Development of Systems for Accelerated Bacteria Collection and Detection (ABCD) Using Electrokinetics (Iterations: 5)

Applications include: Environment, Health/Biomedical





(1) The design is microcantilever-based biosensors to detect E.coli bacteria in real time and very low concentration to meet demands of today`s world. The cantilever will be driven by AC electric potential and the resonance frequencies will be monitored by a laser vibrometer. While the cantilever vibrates, bacteria are adsorbed to its surface using electric field. This causes a shift in the resonance frequency of the cantilever.

(2) The design is microcantilever biosensors to detect various bioparticles such as E.coli bacteria. The target is to detect them in real-time, point-of-care and very low concentrations. The cantilever will be driven by AC electric potential applied on the piezoelectric material. The resonance frequency shift of the cantilever will be monitored when the bioparticles are deposited on it.

(3, 4, 5) The design are microcantilevers which work as biosensors to detect bacteria in water. The target is to detect them in very low concentration within a short time period to meet the demand from the real time monitoring. The piezoelectric material is driven with AC electric potential which in turn causes the cantilever to vibrate. Another AC electric potential is also used to attract bacteria to the cantilever which its resonance frequency shift can be detected.

Queen's University
Designer: Jino Fathy | 17jf14@queensu.ca
Professor: Yongjun Lai | lai@queensu.ca

Graphene Capacitive Pressure Sensor

Applications include: Aerospace, Defence (Safety, Security), Environment, Health/Biomedical

Realization of a novel graphene based capacitive pressure sensor using standard MEMS technology.

University of Waterloo
Designer: Alaaeldin Ahmed | aesamymo@uwaterloo.ca
Professor: Eihab Abdel-Rahman | eihab@uwaterloo.ca

High-Q Micro Resonators

Applications include: Defence (Safety, Security), Pharmaceutical

Improving quality factor and sensitivity of MEMS sensors through anchor isolation.

University of Waterloo
Designer: Alaaeldin Ahmed | aesamymo@uwaterloo.ca
Professor: Eihab Abdel-Rahman | eihab@uwaterloo.ca

Improving the Digital Tuning of Cantilevers

Applications include: Automotive, Environment, Natural Resources/Energy

Working toward the improvement of resonators. These designs aim to improve the previously characterized designs. Tuning the resonant frequency of a resonator is also usually impossible after fabrication. The proposed design should allow modification of the resonant frequency in real time. This is achieved using Electrostatically Controlled Clamps. Previous promising results were achieved however, the performance was hindered by the curling of the cantilevers.

École de technologie supérieure
Designer: Mathieu Gratuze | mathieu.gratuze@etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Integrating a Novel Graphene-polymer Membrane to a Commercial Platform

Applications include: Environment

This project attempts to use the structure of the PiezoMUMPs process to implement an integration platform to realize MEMS capacitive pressure sensors utilizing the novel graphene-polymer heterostructure membrane developed by the Nanofunctional Material Group at the University of Manchester.

Université du Québec à Montréal (UQAM)
Professor: Paul-Vahe Cicek | cicek.paul-vahe@uqam.ca

MEMS Energy Harvesting Systems

Applications include: Environment

The design is going to be used as a vibration-based piezoelectric energy harvester, which converts parasitic environmental vibration into useful electric charges. The proposed structure has an optimized serpentine geometry with the integration of several proof masses at the links for reducing the operational frequency and improving energy conversion efficiency. Thanks to three degrees of freedom, the second and the third mode shapes can be located close to each other, providing a wide-band MEMS energy harvester. Furthermore, the specific geometry for the middle beams helps this device to be more durable. The model is validated by both analytical modeling and finite element simulation to satisfy expected results.

Memorial University
Designer: Aylar Abouzarkhanifard | aabouzarkhan@mun.ca
Professor: Mohammad Al Janaideh | maljanaideh@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

MEMS Micromotor for Optical Swept Filters

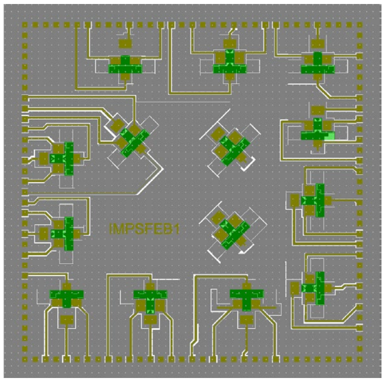
Applications include: Health/Biomedical

The designs proposed are related to micro-opto-electro-mechanical systems and more specifically to develop MEMS micromotors for optical micromechanical systems based swept wavelength component. The micromotor is designed to rotate an integrated polygon mirror at very high speeds inside an optical filter for optical coherence tomography (OCT) applications. The basic design consists of stator poles that surround a circular rotor which rotates about a center bearing. The goal is to achieve optimal torque and angular velocity by fine-tuning the parameters of the design such as the number of poles on the rotor and the stator, as well as reducing friction by using a novel geometrical form for the rotor. The current designs are upgraded version of previous fabricated MEMS micromotors with modification in rotor and stator design for higher torque and smaller motor footprints.

École de technologie supérieure
Designer: Amit Gour | amit.gour.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Micro Resonator Force Sensors

Applications include: Defence (Safety, Security), Aerospace, Automotive



The goal of these designs is to evaluate novel micro resonators designs for high sensitivity force sensing. Our goal is to evaluate these designs for high performance inertial sensors and compare them with other existing academic and industrial solutions.

Simon Fraser University
Designer: Erfan Ghaderi | eghaderi@sfu.ca
Professor: Behraad Bahreyni | behraad_bahreyni@sfu.ca

An Approach to Validate an Electro-thermally Actuated Power MEMS Switches Toward Sustaining High Breakdown Voltage and Power Handling

Applications include: Aerospace

The pathway towards a reliable electro-thermal actuated power MEMS switch using this technology requires a systematic approach to mitigate the effect of joule heating. Here, we implement a chevron (V-shaped) actuator design that incorporates isolation stage and heat sink beams in order to mitigate the elevated temperature across the floating contact.

École de technologie supérieure
Designer: Abdurrashid Hassan Shuaibu | abdurrashid-hassan.shuaibu.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Micro Linear Displacement Sensor v3.0

Applications include: Aerospace, Automotive

The goal is to optimize a novel type of MEMS displacement sensor that is based on resistive contacts. Gemotric amplification will be used to increase the displacement in different directions. This technique allows a better precision in measurement by reducing the minimal displacement of 2 um imposed by the technology. The Si-Si contact model was previously updated with the first generation of MEMS strain sensor. The MEMS device will be integrated with an embedded system to have complete strain sensor system. Different MEMS structures based on contact resistances will be investigated to find the most suitable for strain sensor applications. A post-processing might be done to coat the structures will metal to reduce the overall contact resistance is required. The design will allow to measure displacement from 2 um to 20 um.

École de technologie supérieure
Designer: Alberto Prud'homme | alberto.prudhomme@lacime.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Optimization of electrode configuration for surface-acoustic wave microfluidic sensors / Optimization of surface composition for surface-acoustic wave microfluidic sensors (Iterations: 2)

Applications include: Environment, Health/Biomedical

Surface-acoustic wave sensors are a demonstrated means to achieve sensing of chemical or biological species in microfluidic systems. In the context of lab-on-a-chip implementations, power efficiency and signal sensitivity are of utmost importance. This design attempts to investigate the impact of electrode configuration on surface acoustic love-wave transmission power and linearity, with the goal of determining an optimum design.

Université du Québec à Montréal (UQAM)
Professor: Paul-Vahe Cicek | cicek.paul-vahe@uqam.ca

Phase Comparator and Mode Shape Suppression in MEMS Resonators

Applications include: Environment, ICT (signal processing), Natural Resources/Energy

Working toward the improvement of resonators and their applications. These designs aim to improve the previously characterized designs. Tuning the resonant frequency of a resonator is also usually impossible after fabrication. The proposed design should allow modification of the resonant frequency in real time. This is achieved using Electrostatically Controlled Clamps. Previous promising results were achieved however, the performance was hindered by the curling of the cantilevers.

École de technologie supérieure
Designer: Mathieu Gratuze | mathieu.gratuze@etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

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pMUT Based Particulate Matter Sensors

Applications include: Environment, Health/Biomedical

The goal of the project is to implement a particulate matter sensor based on Piezoelectric Micromachined Ultrasonic Transducers (pMUTs). The fabricated pMUT array will be used to detect mass loading effect on deposition of particulate matter. The transducer will resonate at a frequency of 1 MHz. The resonance frequency is dependent on the physical dimensions of the resonating piezoelectric membrane, and these dimensions are dedicated for sensing the deposition of mass on the membrane. An array of pMUTs with specific dimensions will be implemented, making it highly sensitive and reliable at the same time. This will allow us to determine the mass of the material deposited on the top of the membrane, by measuring the shift in the resonating frequency of the membrane. This array will exploit the advantage of the PiezoMUMPs multi-layer structures to create an array that is optimized for mass sensing.

McGill University
Designer: Navpreet Singh | navpreet.singh@mail.mcgill.ca
Professor: Mourad El-Gamal | mourad.el-gamal@mcgill.ca

Study The Effect of Temperature on MEMS Resonator (Lame Mode)

Applications include: Environment, Health/Biomedical, ICT

MEMS Resonators are designed with different orientation respect to silicon wafer crystal axes. fundamentally, Silicon is an anisotropic material, with elastic behavior that depends on the orientation of the structure, picking the proper value of E (Young's module) for silicon can resemble to be a daunting task. The crystal orientation of the silicon in a silicon wafer has notable impacts on the microfabrication characteristics of the wafer. By changing the resonator orientation E will change properly, therefore, the TCF1 can change respectively. In a specified direction, the resonator has the minimum drift while sweeping the temperature. In conclusion, the right orientation of the resonator will have a minimum effect on TFC1 of the resonator.

École de technologie supérieure
Designer: Amir Reza Kolahdouz Moghaddam | amir-reza.kolahdouz-moghaddam.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Study The Effect of Temperature on Silicon and Create a Temperature Compensated Resonator / High Performance Breath Mode MEMS Resonator with Self Temperature Compensation

Applications include: Automotive, Environment, Health/Biomedical

Temperature plays an important role in the MEMS resonator performance. The MEMS resonator quality can affect the system that is working with the reference clock which is provided by this resonator. In the last decade, many approaches have been presented to overcome the frequency drift during changing ambient temperature. Many researchers use costly and complex techniques to make the frequency steady in different ranges of temperatures. In this design, we are going to use a mechanical approach using Silicon orientation to compensate for the temperature rise. In this design, I designed a temperature sensor to sense the die temperature in order to have a reference and accurate measurement. The novelty of this design is aimed to be the passive approach to compensate for the temperature without using energy and also use different input and output to select the best temperature-compensated design. The devices will be used for timing and sensing applications.

École de technologie supérieure
Designer: Amir Reza Kolahdouz Moghaddam | amir-reza.kolahdouz-moghaddam.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Technology: PolyMUMPs

MEMSCAP PolyMUMPs

Agricultural Gas Sensors

Applications include: Environment

Regarding our design, each sensor on the chip has a plate carried by two curved-up cantilever beams above an actuating electrode and another landing electrode.

University of Waterloo
Designer: Yasser Sayed Ahmed Abdelaziz Mahrous Shama | ys2shama@uwaterloo.ca
Professor: Eihab Abdel-Rahman | eihab@uwaterloo.ca

Graphene Collaboration
Applications include: Environment

Graphene collaboration, investigation of the potential creation of mixed PolyMUMPs MEMS with a graphene layer. This design investigates the reinforcement of MEMS resonators with a graphene layer.

École de technologie supérieure
Designer: Mathieu Gratuze | mathieu.gratuze@etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Capacitive Flow sensors
Applications include: Automotive, Environment, Health/Biomedical

Working toward the design of new CMUTS (Capacitive Micromachined Ultrasonic Transducers). Designs have been prototyped using simulation and real-life measurements. These designs allow a higher displacement and a better control of the resonant frequency. These designs will also allow us the design of compact elements with high resonant frequency (>5MHz). The designs submitted in this area will allow real-life measurements.

École de technologie supérieure
Designer: Amirhossein Moshrefi | amirhossein.moshrefi.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Chevron (V-shaped) Type Thermal Actuated MEMS Switches
Applications include: Aerospace

The pathway towards a reliable electro-thermal actuated power MEMS switch using this technology requires a systematic approach to mitigate the effect of joule heating. Here, we implement a chevron (V-shaped) actuator design that incorporates isolation stage and heat sink beams in order to mitigate the elevated temperature across the floating contact.

École de technologie supérieure
Designer: Amirhossein Moshrefi | amirhossein.moshrefi.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

Design of CMUTs with Novel Actuation Methods
Applications include: Automotive, Entertainment

The project consists of implementing a novel actuation method for capacitive micro-machined ultrasonic transducers. The focus of the research is to explore the possibility of fabricating such devices in the standard PolyMUMPs process. The goal of the project is to control the electrodes using electrostatic actuation to achieve a repulsive membrane deflection. Several variations of the design will be implemented to investigate the effect of the different structural parameters on the performance of the devices

McGill University
Designer: Roufaida Bensalem | rofaida.bensalem@mail.mcgill.ca
Professor: Mourad El-Gamal | mourad.el-gamal@mcgill.ca

Low Frequency Capacitive Micromachined Ultrasonic Transducers for Air-coupled Range Finding Applications

Applications include: Automotive, Defence (Safety, Security), Agriculture/Agri-Food

Capacitive Micromachined Ultrasonic Transducers (CMUT) are devices of high interest as they can replace piezoelectric ultrasonic probe transducers while reducing the overall cost and size of electronics. As such, CMUTs are integrated several devices in a wide range of different applications: anemometry, flow sensing, gas sensing, etc. The purpose of this project is to design a low frequency ultrasonic transducer array (less than 100 kHz) that is more suited for air-coupled ranging applications while requiring an adequate pull-in voltage.

McGill University
Designer: Ayoub Bouhemhem | ayoub.bouhemhem@mail.mcgill.ca
Professor: Mourad El-Gamal | mourad.el-gamal@mcgill.ca

MEMS Accelerometer

Applications include: Automotive

MEMS based environmentally robust accelerometer for automotive applications.

University of Windsor
Designer: Ankang Wang | wang119f@uwindsor.ca
Professor: Jalal Mohammed Ahamed | jahamed@uwindsor.ca

MEMS Energy Harvester

Applications include: Environment, Health/Biomedical

MEMS floated structures used to create inductance for Energy Harvesting applications. Multiple turn metal layer will be made like a spring to create the inductance used for the harvester design.

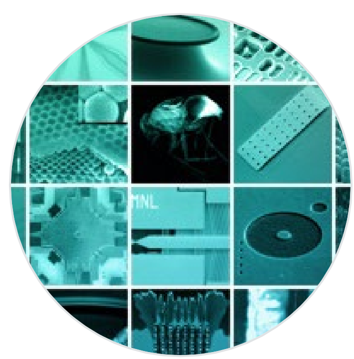
Queen's University
Designer: Hosein Zreie | hz32@queensu.ca
Professor: Majid Pahlevani | majid.pahlevani@queensu.ca

Polymer-based Sensor Array

Applications include: Agriculture/Agri-Food

Impedance-based polymer sensor arrays.

University of Windsor
Designer: Calvin Love | lovec@uwindsor.ca
Professor: Arezoo Emadi | arezoo.emadi@uwindsor.ca



MNT (Micro-Nano Technology) FABRICATION

CMC’s MNT Portal includes **40** facilities located at universities across Canada offering custom fabrication - mask generation, etching, materials deposition, lithography, and characterization.

Academic researchers receive an award of 80% of project expenses to reduce the costs of accessing university-based MNT labs. This report describes designs that benefited from CMC’s financial assistance MNT Award. **Learn more:** www.cmc.ca/MNT

MNT: MEMS

- Enhancement of magnetoresistance in single-layer graphene transistors by means of supramolecular lattices
  Application: ICT (nanotechnology, magnetoresistance sensors) |
  MNT: Laboratory of Micro and Nanofabrication (LMN)
  Institut national de la recherche scientifique (INRS)
  Designer: Atiye Pezeshki | E: atiye.pezeshki@emt.inrs.ca
  Professor: Emanuele Orgiu | E: emanuele.orgiu@inrs.ca

- Fabricating optomechanical devices for quantum transducing application
  Application: Aerospace, Defence (Safety, Security), ICT | MNT: nanoFAB, University of Alberta
  University of Calgary
  Designer: Trong Ngo | E: huynhbuutrong.ngo@ucalgary.ca
  Professor: Paul Barclay | E: pbarclay@ucalgary.ca

- Highly doped silicon heater for near-field thermophotovoltaic experiment
  Application: Natural Resources/Energy | MNT: Centre for Research in Photonics (CRP)
  University of Ottawa
  Designer: Chang Zhang | E: czhan092@uottawa.ca
  Professor: Raphael St-Gelais | E: raphael.stgelais@uottawa.ca

- RF MEMS and antenna elements on composite substrates
  Application: Aerospace | MNT: Nano Systems Fabrication Laboratory (NSFL)
  University of Manitoba
  Designer: Shrin Ramezanzadehyazdi | E: ramezans@myumanitoba.ca
  Professor: Cyrus Shafai | E: cyrus.shafai@umanitoba.ca

- Water salinity micro sensor
  Application: Agriculture/Agri-Food, Defence (Safety, Security) Environment, Health/Biomedical |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Alaaeldin Ahmed | E: alaaeldin.ahmed@uwaterloo.ca
  Professor: Eihab Abdel-Rahman | E: eihab@uwaterloo.ca

- Wireless telemetry for pressure sensing inside the kidneys
  Application: Health/Biomedical | MNT: SBQMI Advanced Nanofabrication Facility (ANF)
  University of British Columbia
  Designer: Mohammadreza Yousefidarestani | E: darestani@ece.ubc.ca
  Professor: Kenichi Takahata | E: takahata@ece.ubc.ca

MNT: Microfluidics

- Alternating current electrothermal micropumps for biomicrofluidics
  Application: Health/Biomedical | MNT: Microsystems Hub
  University of Calgary
  Designer: Thomas Lijnse | E: thomas.lijnse@ucalgary.ca
  Professor: Colin Dalton | E: cdalton@ucalgary.ca

- Optoelectronic tweezers for cell sorting
  Application: Health/Biomed |
  MNT: Centre for Microfluidic Systems in Chemistry and Biology (CMS)
  University of Toronto
  Designer: Mohamed Elsayed | E: mohammed.elsayed@mail.utoronto.ca
  Professor: Aaron Wheeler | E: aaron.wheeler@utoronto.ca

MNT: Micromachining

- Fabrication of polymer-based ultrasound sensors
  Application: Health/Biomedical | MNT: SBQMI Advanced Nanofabrication Facility (ANF)
  University of British Columbia
  Designer: Carlos Gerardo | E: cgerardo@ece.ubc.ca
  Professor: Edmond Cretu | E: edmondc@ece.ubc.ca

- Silicon Micromachined Waveguide Millimeter-Wave Switch using Photo-Induced Solid-State Plasma
  Application: Aerospace, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Thomas Jones | E: email
  Professor: Douglas Barlage | E: email

MNT: Nanotechnology

- A Carbon nanotube field emission multi-pixel X-ray source for fluence field modulated computational tomography
  Application: Health/Biomedical (Biomedical imaging, cancer diagnosis) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Elahe Cheraghi | E: echeragh@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- Characterization of superconducting aluminum air bridges fabricated from one-step EBL process
  Application: ICT | MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Noah Janzen | E: noah.janzen@uwaterloo.ca
  Professor: Adrian Lupascu | E: alupascu@uwaterloo.ca

- Coatings by Design for Lithium Ion Batteries: Enhancing energy efficiency and power while improving materials durability
  Application: Environment, Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Gurbinder Kaur | E: gurbinder_kaur@sfu.ca
  Professor: Byron Gates | E: bgates@sfu.ca

- CVD graphene hall bar device
  Application: ICT (spintronics) | MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Mai Sakuragi | E: msakuragi@uwaterloo.ca
  Professor: Na Young Kim | E: nayoung.kim@uwaterloo.ca

- Cytokine biosensor application using WS2 nanocrystals
  Application: Health/Biomedical | MNT: 4D LABS
  Simon Fraser University
  Designer: GL Thushani De Silva | E: g_l_thushani_de_silva@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Fabrication and characterization of 2D bipolar junction transistors using photoinduced doping effect
  Application: ICT | MNT: 4D LABS
  Simon Fraser University
  Designer: Abdelrahman Askar | E: aaskar@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Fabrication and characterization of MoS2-channel FETs
  Application: Health/Biomedical | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Andres Forero Pico | E: foreropi@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- Fabrication of porous electrodes of organic transistors
  Application: ICT (electronics, material science) | MNT: Laboratory of Micro and Nanofabrication (LMN)
  Institut national de la recherche scientifique (INRS)
  Designer: Ilknur Eryilmaz | E: zuchong.yang@emt.inrs.ca
  Professor: Emanuele Orgiu | E: emanuele.orgiu@inrs.ca

- Fabrication of ultra-thin mono-crystalline silicon solar cell
  Application: Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Ribwar Ahmadi | E: ribwara@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Field-effect biosensor based on supramolecular lattice/graphene van der Waals heterostructure
  Application: Health/Biomedical | MNT: Laboratory of Micro and Nanofabrication (LMN)
  Institut national de la recherche scientifique (INRS)
  Designer: Zuchong Yang | E: zuchong.yang@emt.inrs.ca
  Professor: Emanuele Orgiu | E: emanuele.orgiu@inrs.ca

- Flexible and stretchable piezoelectric nanogenrators
  Application: Natural Resources/Energy | MNT: GCM Lab
  Polytechnique Montréal
  Designer: Mina Abbasipour | E: mina.abbasipour@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- High-Performance, flexible hybrid TMDC FET with tunable electronic and optical properties, fabrication and new analytical methods
  Application: Health/Biomedical, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Junsen Gao | E: junsen@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- Highly stable 2D tellurene high frequency transistors
  Application: ICT | MNT: 4D LABS
  Simon Fraser University
  Designer: Abdelrahman Askar | E: aaskar@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Microstructured 3D-printed terahertz horn antennas
  Application: Defence (Safety, Security), Entertainment, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Basem Shahriar | E: bshahria@ualberta.ca
  Professor: Abdulhakem Elezzabi | E: elezzabi@ualberta.ca

- Mobility- & contact-resistance-engineered, 2D field effect transistors for high-frequency applications
  Application: ICT | MNT: 4D LABS
  Simon Fraser University
  Designer: Abdelrahman Askar | E: aaskar@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Nanofabrication and characterization of a finely featured gold metasurface
  Application: Environment, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Mitchell Semple | E: msemple@ualberta.ca
  Professor: Ashwin Iyer | E: iyer@ece.ualberta.ca

- Nanostructured spintronic terahertz emitters
  Application: Defence, Safety, and Security, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Basem Shahriar | E: bshahria@ualberta.ca
  Professor: Abdulhakem Elezzabi | E: elezzabi@ualberta.ca

- Organic magnetoresistance in field-effect transistor
  Application: ICT (electronics) | MNT: Laboratory of Micro and Nanofabrication (LMN)
  Institut national de la recherche scientifique (INRS)
  Designer: Zuchong Yang | E: zuchong.yang@emt.inrs.ca
  Professor: Emanuele Orgiu | E: emanuele.orgiu@inrs.ca

- Palladium nickel nanoparticles as a catalyst for the oxygen reduction reaction for fuel cell applications
  Application: Aerospace, Automotive, Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Merissa Schneider-Coppolino | E: merissas@sfu.ca
  Professor: Byron Gates | E: bgates@sfu.ca

- Preparation of porous platinum using surfactant-assisted electrodeposition for oxygen reduction in polymer electrolyte membrane fuel cells
  Application: Natural Resources/Energy, Aerospace, Automotive | MNT: 4D LABS
  Simon Fraser University
  Designer: Sakshi Sakshi | E: ssakshi@sfu.ca
  Professor: Byron Gates | E: bgates@sfu.ca

- Process optimization and characterization of one-step EBL aluminum air bridges for superconducting quantum devices
  Application: ICT | MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Noah Janzen | E: noah.janzen@uwaterloo.ca
  Professor: Adrian Lupascu | E: alupascu@uwaterloo.ca

- Surface effect of gold and copper alloy nanoparticle growth
  Application: Aerospace, Automotive, Environment, Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Albert Adserias | E: albert_adserias@sfu.ca
  Professor: Gary Leach | E: gary_leach@sfu.ca

- Synaptic emulation with memristor devices
  Application: Defence (Safety, Security), ICT | MNT: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Joel Loh | E: joel.loh@mail.utoronto.ca
  Professor: Nazir Kherani | E: nazir.kherani@utoronto.ca

- Synthesis and analysis of mesoporous sulfur materials for possible use in energy storage and related application
  Application: Environment, Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Mi Win | E: mmumuwin@sfu.ca
  Professor: Byron Gates | E: bgates@sfu.ca

- Terahertz emission from metal-doped Pt films with an enhanced spin Hall angle
  Application: Defence, Safety, and Security, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Basem Shahriar | E: bshahria@ualberta.ca
  Professor: Abdulhakem Elezzabi | E: elezzabi@ualberta.ca

- Ultra-band terahertz detector
  Application: Health/Biomedical (image detection) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Zhemiao Xie | E: z73xie@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- Ultrahigh sensitive fully-suspended CVD-grown WS2 photodetectors
  Application: Defence (Safety, Security), Environment, Health/Biomedical | MNT: 4D LABS
  Simon Fraser University
  Designer: Amin Abnavi | E: amin_abnavi@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

MNT: Photonics

- AlGaAs Bragg reflection waveguide lasers for quantum state generation
  Application: ICT (quantum computation) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Toronto
  Designer: Trevor Stirling | E: trevor.stirling@mail.utoronto.ca
  Professor: Amr Helmy | E: a.helmy@utoronto.ca

- Anisotropic wet etching for fabrication of in plane Fabry-Perot interferometer on Si <110> for gas sensor applications
  Application: Agriculture/Agri-Food, Environment, Natural Resources/Energy | MNT: GCM Lab
  Polytechnique Montréal
  Designer: Régis Guertin | E: regis.guertin@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- CMOS compatible Bragg reflection waveguides for second harmonic generation
  Application: ICT (computation / quantum computers) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Toronto
  Designer: Trevor Stirling | E: trevor.stirling@mail.utoronto.ca
  Professor: Amr Helmy | E: a.helmy@utoronto.ca

- Electrochromic phase modulation for buried SiN and LiNbO3 waveguides
  Application: Defence, Safety, and Security, ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Eric Hopmann | E: hopmann@ualberta.ca
  Professor: Abdulhakem Elezzabi | E: elezzabi@ualberta.ca

- Enhanced evanescent field polymer waveguide on porous silica cladding fabrication
  Application: Agriculture/Agri-Food, Environment | MNT: 3IT.Nano
  Université de Sherbrooke
  Designer: Pauline Girault | E: pauline.girault@usherbrooke.ca
  Professor: Paul Charette | E: paul.charette@usherbrooke.ca

- Fabrication of chiral plasmonic metasurface array
  Application: Automotive, Defence (Safety, Security), Entertainment, ICT | MNT: 4D LABS
  Simon Fraser University
  Designer: Sasan V. Grayli | E: sasanv@sfu.ca
  Professor: Gary Leach | E: gary_leach@sfu.ca

- GaN based UV LEDs for UV disinfection and water purification
  Application: ICT (display technologies, consumer electronics), Health/Biomedical (smart heath) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Roksana Rashid | E: roksanarashid@uwaterloo.ca
  Professor: William Wong | E: wswong@uwaterloo.ca

- Gas sensor based on whispering gallery mode cavities made of SU-8 polymer integrated on chip
  Application: Agriculture/Agri-Food, Defence (Safety, Security), Environment, Health/Biomedical, Natural Resources/Energy | MNT: GCM Lab
  Polytechnique Montréal
  Designer: Marc-Antoine Bianki | E: marc-antoine.bianki@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- Graphene-Carbon nanotube photodetector
  Application: Defence (Safety, Security), Health/Biomedical |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: HeeBong Yang | E: heebong.yang@uwaterloo.ca
  Professor: Na Young Kim | E: nayoung.kim@uwaterloo.ca

- Hybrid plasmonic Au-MoS2-Au nanostructure based device for biosensing
  Application: Health/Biomedical | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Dipanjan Nandi | E: dipanjan@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- Hyperbolic metamaterials for visible light photo-catalysis for the generation of solar fuel
  Application: Environment | MNT: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Joel Loh | E: joel.loh@mail.utoronto.ca
  Professor: Nazir Kherani | E: nazir.kherani@utoronto.ca

- Multidimensional ultrasonic detection using optical micro-resonators
  Application: Agriculture/Agri-Food, Environment, Natural Resources/Energy | MNT: GCM Lab
  Polytechnique Montréal
  Designer: Ahmed Sami Bahgat Abdelaziz | E: ahmed-s.bahgat@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- On-chip colloidal quantum dot photodetector
  Application: Automotive, ICT (night vision, remote sensing), Health/Biomedical (medical imaging) |
  MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Qiwei Xu | E: qxu1@ualberta.ca
  Professor: Xihua Wang | E: xihua@ualberta.ca

- Optical fiber and waveguide integrated phase-change metamaterial modulators for telecommunications
  Application: ICT | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Yihao Cui | E: yihao2+cmc@ualberta.ca
  Professor: Behrad Gholipour | E: bgholipo@ualberta.ca

- Optical-fiber integrated nanophotonic metamaterial sensors
  Application: Automotive, Environment, Natural Resources/Energy | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Josh Perkins | E: jperkins@ualberta.ca
  Professor: Behrad Gholipour | E: bgholipo@ualberta.ca

- Planar multilayer window coating for indoor thermal management
  Application: Natural Resources/Energy | MNT: NanoFabrication Kingston (NFK)
  Queen's University
  Designer: Muhammad Asad | E: 19msa4@queensu.ca
  Professor: Muhammad Alam | E: m.alam@queensu.ca

- Post-processing of foundry-fabricated photonic crystal directional coupler-based ultrasonic sensors
  Application: ICT (ultrasonic sensors) |
  MNT: Western Nanofabrication Facility & nanoFAB, University of Alberta
  Western University
  Designer: Michael Zylstra | E: mzylstra@uwo.ca
  Professor: Jayshri Sabarinathan | E: jsabarin@uwo.ca

- Randomly addressable multifunctional pixelated metasurface based on crossbar architecture
  Application: Defence (Safety, Security), Environment, Health/Biomedical, Aerospace, Natural Resources/ Energy | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Avik Mandal | E: amandal1@ualberta.ca
  Professor: Behrad Gholipour | E: bgholipo@ualberta.ca

- Single mode high power Bragg reflection waveguide laser diode for second harmonic generation
  Application: ICT (quantum imaging and quantum communication) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Toronto
  Designer: Bilal Janjua | E: bilal.janjua@utoronto.ca
  Professor: Amr Helmy | E: a.helmy@utoronto.ca

- Stable NIR photodiode based on Si/ink CQD heterojunction
  Application: ICT, Health/Biomedical | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Qiwei Xu | E: qxu1@ualberta.ca
  Professor: Xihua Wang | E: xihua@ualberta.ca

- Strong coupling of quantum emitters
  Application: Defence (Safety, Security), ICT (Quantum Information) | MNT: 4D LABS
  Simon Fraser University
  Designer: Albert Adserias | E: albert_adserias@sfu.ca
  Professor: Gary Leach | E: gary_leach@sfu.ca

- TMD based solar cell
  Application: Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Fahmid Kabir | E: fahmid_kabir@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Transfer printing III-V quantum photonic devices on heterosubstrates: towards high performance and new functionalities
  Application: Aerospace, Environment, Health/Biomedical |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Siyi Wang | E: s535wang@uwaterloo.ca
  Professor: Dayan Ban | E: dban@uwaterloo.ca

- Ultra fast thermoplasmonics coupling on nanostructured arrays
  Application: Health/Biomedical, Natural Resources/Energy | MNT: 3IT.Nano
  Université de Sherbrooke
  Designer: Jean-François Bryche | E: jean-francois.bryche@usherbrooke.ca
  Professor: Paul Charette | E: paul.charette@usherbrooke.ca

- Uncooled infrared detector based on MXene materials
  Application: Health/Biomedical (wearable devices) |
  MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Jiaqi Wang | E: j767wang@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

MNT: Quantum

- Fabrication and characterization of superconducting devices with improved coherence using improved materials and processes
  Application: ICT | MNT: Quantum-Nano Fabrication and Characterization Facility (QNFCF)
  University of Waterloo
  Designer: Rui Yang | E: r249yang@uwaterloo.ca
  Professor: Adrian Lupascu | E: alupascu@uwaterloo.ca

MNT: Other Technologies

III-V High Power Electronics

- Techniques for improving the linearity of lattice-matched InAlN/GaN HFETs
  Application: ICT | MNT: McGill Nanotools Microfab
  Concordia University
  Designer: Mehrnegar Aghayan | E: mn.aghayan@gmail.com
  Professor: Pouya Valizadeh | E: pouya@ece.concordia.ca

Biosensing

- Fabrication and characterization of accumulation mode Organic Electrochemical Transistors (OECTs) with n-type small molecule organic semiconductors
  Application: Other (biosensor) | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Seongdae Kang | E: seongdae@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- Organic electrochemical transistor optimization for biosensing applications
  Application: Other (biosensor) | MNT: nanoFAB, University of Alberta
  University of Alberta
  Designer: Jiaxin Fan | E: fan1@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

Characterization

- A Pre-Clinical Evaluation of Protein Nanoparticles for X-ray Triggered Drug Release
  Application: Health/Biomedical, Pharmaceutical (Biopharmaceutical, Chemical) | MNT: 4D LABS
  Simon Fraser University
  Designer: Courtney Van Ballegooie | E: cvanball@sfu.ca
  Professor: Byron Gates | E: bgates@sfu.ca

- An ultralight and flexible conducting polymer sponge for high electromagnetic interference shielding applications
  Application: Defence (Safety, Security) | MNT: GCM Lab
  Polytechnique Montréal
  Designer: Biporjoy Sarkar | E: biporjoy.sarkar@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- FIB technique for battery materials
  Application: Automotive, Natural Resources/Energy | MNT: 4D LABS
  Simon Fraser University
  Designer: Alexi Pauls | E: alexi_pauls@sfu.ca
  Professor: Byron Gates | E: bgates@sfu.ca

- Stretchable and self-healable conducting polymers for wearable electronics
  Application: Health/Biomedical | MNT: GCM Lab
  Polytechnique Montréal
  Designer: Michel Bilodeau-Calame | E: michel.bilodeau-calame@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

Microfabrication & Nanofabrication

- Manufacturing of TMD-FET: field effect transistors based on transition metal dichalcogenides
  Application: ICT (materials science, microelectronic device engineering), Natural Resource/Energy | MNT: Laboratory of Micro and Nanofabrication (LMN)
  Institut national de la recherche scientifique (INRS)
  Designer: Anoir Hamdi | E: anoir.hamdi@emt.inrs.ca
  Professor: Emanuele Orgiu | E: emanuele.orgiu@inrs.ca

- Study of the effect of different types of ionic liquids on the electrical properties of field effect transistors (FETs) based on MoS2 and WSe2
  Application: Natural Resources/Energy | MNT: Laboratory of Micro and Nanofabrication (LMN)
  Institut national de la recherche scientifique (INRS)
  Designer: Anoir Hamdi | E: anoir.hamdi@emt.inrs.ca
  Professor: Emanuele Orgiu | E: emanuele.orgiu@inrs.ca

Appendix A-1 – A Canada-wide collaboration

CMC manages Canada's National Design Network® (CNDN), a Canada-wide collaboration between over 65 post-secondary institutions to connect 10,000 academic participants with 1,000 Canadian companies to design, make and test micro-nanosystem prototypes.

Annually

- 1 330 connected professors
- 6 885 researchers
- 355 collaborations with industry, value: 28.9M
- 15 new start-ups (recent 5-year average)
- 610 trained HQP move to industry in Canada

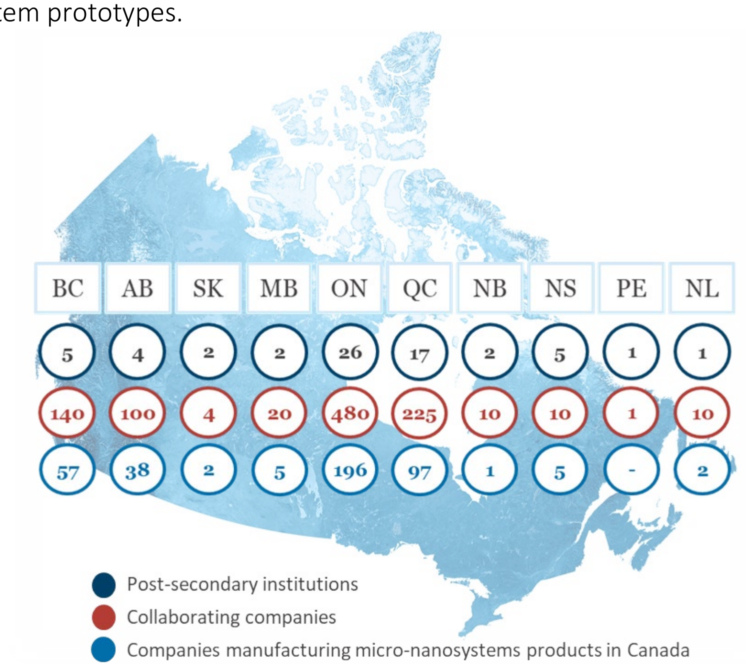


Figure A.1 - CNDN Outcomes 2020/21

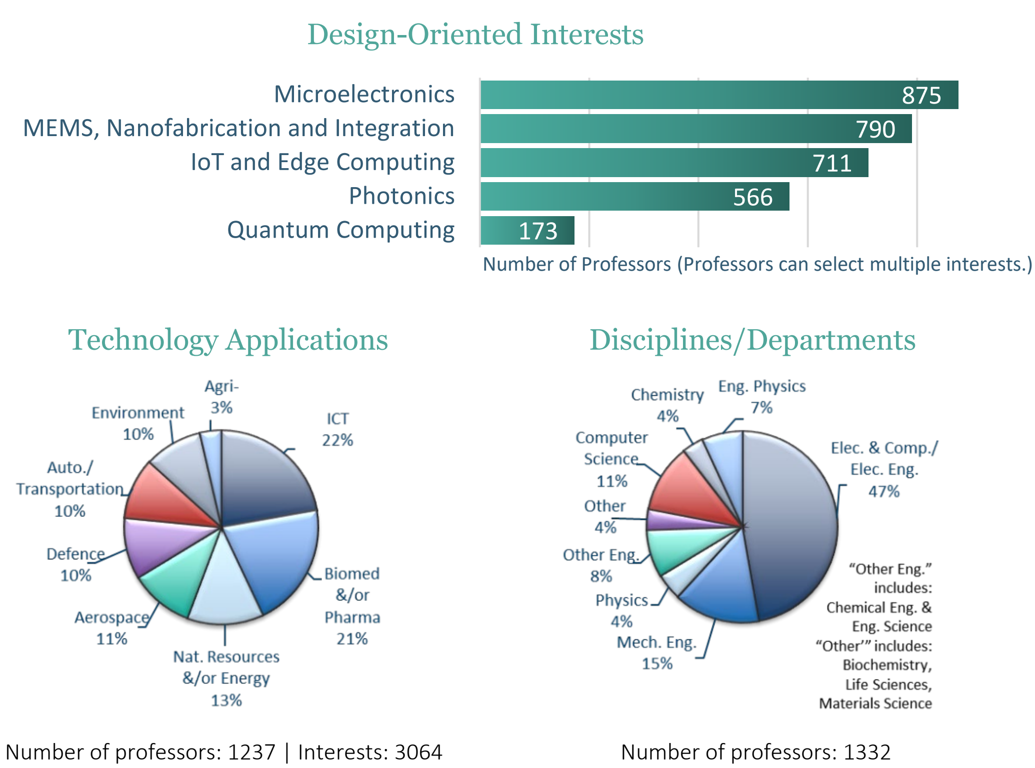
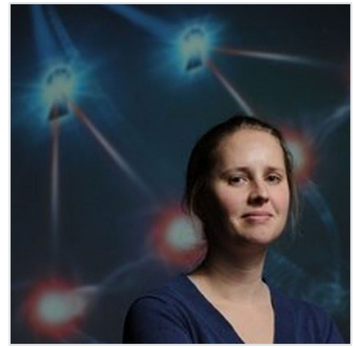


Figure A.2 - CNDN Academic Landscape 2020/21

Appendix A-2 – Success stories

To read CMC Success Stories, including the examples listed below, see www.CMC.ca/SuccessStories.



A quantum leap in cybersecurity

Anne Broadbent, Carlisle Adams, and Sherry Wang
University of British Columbia

In the post-quantum world, the password authentication schemes that companies and consumers rely on for secure transactions will be more vulnerable to attack. A team of researchers at the University of Ottawa is working on a way to foil cybercriminals in the not-so-distant future.

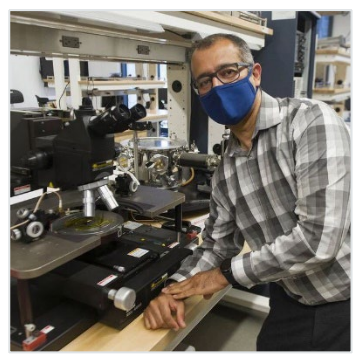
- Published February 2022

Toward an energy efficient future – at the atomic level

Taleana Huff, University of Alberta

Taleana Huff won the 2021 CMC Microsystem's Douglas R. Colton Medal for Research Excellence for work that lays the foundation for computers and mobile phones that use 100 times less energy. Huff's doctoral research at the University of Alberta could enable a new system architecture for information storage and computation that is based on atom-sized building blocks.

- Published November 2020

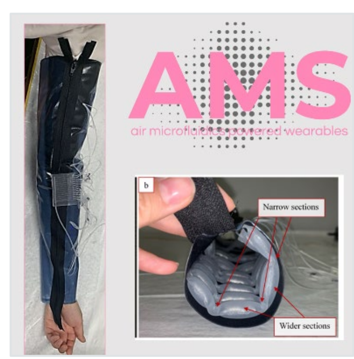


Sensors headed to the moon

Behraad Bahreyni, Simon Fraser University

In May 2021, the Canadian Space Agency chose the team (Glen Williams-Jones at SFU, Yajing Liu at McGill U, Philip Ferguson and Pooneh Maghoul at U Manitoba) to provide miniaturized instruments for a rover that will conduct high-resolution studies of the lunar subsurface in the polar region of the Moon. It's part of a joint mission with NASA that is expected to launch by 2026.

- Published October 2021



Using microfluidics to help breast cancer survivors heal and recover

Run Ze Gao and Carolyn Ren, University of Waterloo

Gao and Ren have developed a wearable, next generation pneumatic massage sleeve for patients with breast cancer-related lymphedema. The condition, often chronic, affects more than 50 per cent of breast cancer survivors who had lymph nodes removed or damaged in their breast cancer treatment. The sleeve is lighter and less restrictive than the bulky systems currently used.

- Published July 2021

Appendix B-1 – Technology development for strategic sectors

Strategic Direction

CMC’s strategic direction aims to maximize impact on Canadian research, innovation, and economic growth. Microelectronics, photonics, optoelectronics, micromachining, embedded software, and nano-scale technologies are enabling progress in numerous scientific disciplines. These microsystem technologies contribute to innovative applications in sectors identified by Canada’s Economic Strategy Tables.

Figure B.1 – Technology Development for Strategic Sectors

Strategic Technology Development

By enabling access to advanced tools and technologies, the CNDN furthers Canada’s leadership in technologies – and drivers including the Internet of Things (IoT) and Edge Artificial Intelligence (AI) – foundational to a thriving digital economy.

www.CMC.ca/Strategic-Technologies

Appendix B-2 – CMC Technology Roadmap

New and in development prototyping capabilities

CMC plays an enabling role in providing tools, technologies, and expertise to advance Canada's digital economy – where microchip (chip) advanced technologies are critical.

Introduced in 2021/22:

Microelectronics & Packaging

- Taiwan Semiconductor Manufacturing Company (TSMC) 28nm
- Micross wafer-level bumping supplier (tested on TSMC 180nm)
- X-FAB Automotive 180 nm BCD-on-SOI Technology Platform

Photonics

- Advanced Micro foundry (AMF) silicon nitride (SiN) process
- e-beam service
- GlobalFoundries®: 45CLO silicon photonics PDK (Beta release in 2021; available July 2022)

IoT and Edge AI

- Mitacs RISC-V Based HW Acceleration for Deep Learning
- Atlas 200 DK – AI Developer Kit Model
- Huawei Canada supercomputer and AI Clusters
- IoT Mote
- Deeplite Neutrino on CMC AI cluster
- CMC equipment pool additions: Edgewater Wireless Access Point; Xilinx RFSoCx2 Dev Kits; Xilinx VCK190 Versal dev kit

Quantum

- Superconducting device multi-project wafer (MPW) (StarCRYO).
- Publication of codes (GitHub): Password-Based User Authentication, Grover's Algorithm for protein design, non-destructive underground object detection, tutorial codes for Xanadu's Gaussian Boson Sampling (GBS) system.
- In 2020/21, CMC joined the IBM Quantum Hub, making IBM's most powerful (127-bit) quantum computer available in Canada for the first time. Additionally, with Canadian firm Xanadu Quantum Technologies, we launched the Quantum Sandbox.

Micro Electro-Mechanical Systems (MEMS), Nanofabrication, Integration

- 2.5D Silicon Interposer
- BGA packaging for CMOS chips
- Electronic Sensor Platform (ESP): microfluidic integration and evaluation board
- SilTerra pMUT MEMS process

Fabrication Training Workshops: CMC Basecamp design-fabrication-test courses include:

- Advanced CMOS Design (FinFET)
- Analog and Mixed Signal design methodology and FinFET layout using GF12nm PDK
- SiEPIC Passive and Active Photonics – targeting AMF Silicon Photonics and ANT NanoSOI technologies available through CMC Microsystems
- Superconducting Circuits (device workshop)
- Silicon Interposer (underway)

FAB

Appendix C – Fabrication services for prototypes

View our FAB schedule online:

www.cmc.ca/FAB

Microelectronics

- STMicroelectronics FD SOI 28nm CMOS
- TSMC - options:
  - 65nm GP CMOS, 65nm LP CMOS, 28nm CMOS, 0.13µm CMOS, 0.18µm CMOS BDC, 0.18µm CMOS, 0.35µm CMOS
- AMS 0.35µm CMOS - options:
  - Standard, Opto, High Voltage, Post Processing
- GlobalFoundries® - options:
  - 12LP FinFET, 22FDXTM FDSOI 22 nm, 45 nm RFSOI, 90 nm BiCMOS SiGe 9HP, 130 nm BiCMOS SiGe 8XP

Photonics & Optoelectronics

- AMF Silicon on Insulator, Passives and Actives
- Applied Nanotools (ANT) NanoSOI
- GlobalFoundries® - CMOS-photonics options:
  - 90WG, 45CLO
- Canadian Photonics Fabrication Centre (NRC-CPFC) III-V Epitaxy on InP Substrates
- FBH-Berlin III-V Epitaxy on GaAs Substrates
- Landmark III-V Epitaxy on GaAs and InP Substrates

Micro Electro-Mechanical Systems (MEMS)

- MEMSCAP PiezoMUMPs
- MEMSCAP PolyMUMPs
- MEMSCAP - Post-processing for PolyMUMPS
- Teledyne DALSA MIDIS™ Platform
- Teledyne Micralyne MicraGEM-Si™
- Electronic Sensor Platform (ESP)

Micro-Nano Technologies (MNT) Facilities

- 40+ facilities located at universities across Canada

Contact us

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