CMC MICROSYSTEMS

Designs in Fabrication

Canada's National Design Network®

Prototyping Report:

April 2018 – March 2019

About CMC Microsystems and Canada's National Design Network®

CMC Microsystems (CMC) provides services essential for the research and training required to advance Canada's digital economy, for example, Industry 4.0, autonomous vehicles, big data, Internet of Things (IoT), cyber defence/security, 5G, quantum computing, artificial intelligence (AI) and more! CMC manages Canada's National Design Network (CNDN).

CMC Microsystems' fabrication reports describing Canada's National Design Network designs that have progressed to fabrication are published for distribution at www.cmc.ca

www.CMC.ca

CMC Microsystems Fabrication Report, 2018/19
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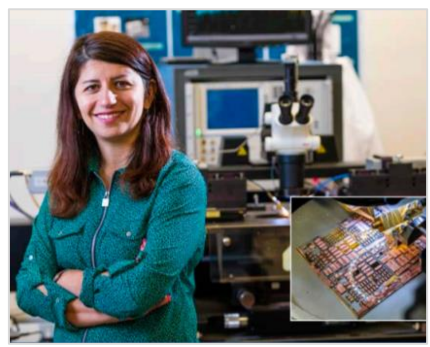
For inquiries about this publication: Pat.Botsford@cmc.ca

January 2020 - **Remembering the professors and students we lost on Ukraine International Airlines Flight 752**

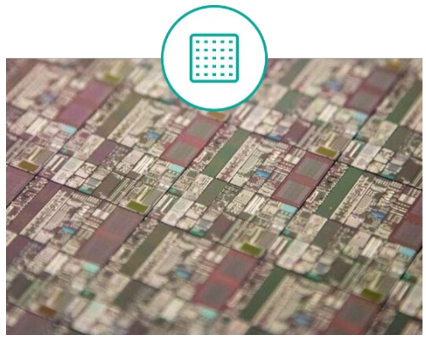
We join in sorrow with others across Canada's National Design Network as we remember the many brilliant and budding researchers who lost their lives on Flight PS752. Honouring victims from our own community we remember: Iman Aghabali and Mehdi Eshaghian, PhD students from McMaster; Mojtaba Abasnezhad, PhD candidate in Toronto, and; Dr. Mojgan Daneshmand and Dr. Pedram Mousavi from Alberta, highly engaged professors who demonstrated great excitement for research, for innovation, for students, and for contributing their skills and insight in support of the entire microsystems community in Canada.

Mojgan and Pedram's passion for research will continue to inspire generations of young researchers.

A scholarship for graduate students at the University of Alberta has been established under the Mojgan Daneshmand, Pedram Mousavi & Victims of Flight PS752 Memorial Fund. To learn more visit **CanadaHelps** at www.canadahelps.org.



Dr. Mojgan Daneshmand

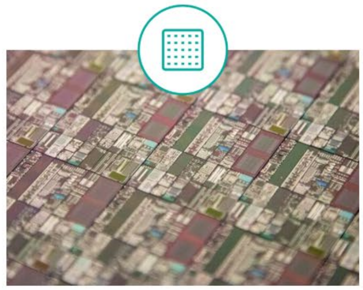


INTRODUCTION

Lowering barriers to technology adoption: CMC delivers key services to increase researchers' and companies' innovation capability in Canada, including industrial-scale multi-project wafer (MPW) manufacturing services, value-added packaging and assembly services and in-house expertise for first-time-right prototypes. Support is available for industrial projects and academic R&D.

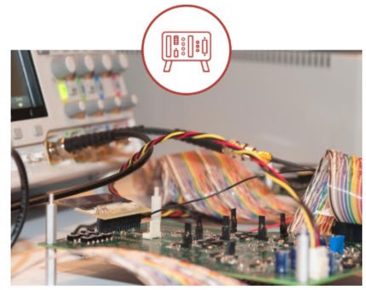
CAD

State-of-the-art environments for successful design



FAB

Services for making working prototypes



LAB

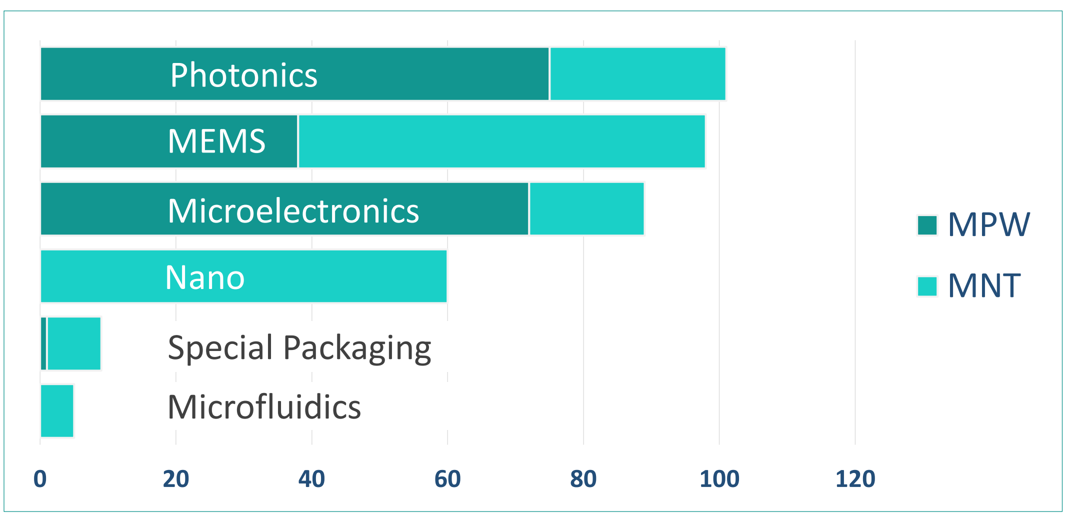
Equipment for device validation to system demonstration

This report describes designs that have progressed to fabrication (FAB) for prototype purposes within **2018/19**. It provides a view into the activities of researchers in Canadian post-secondary institutions – often in the context of applications and solving problems.

FAB Highlights: 2018/19

In this period, **362** designs were fabricated.

- **351** designs for **84** professors and **347** graduate students from **26** Canadian institutions
- **11** designs for **8** Canadian and international companies



- Multi-Project Wafer (MPW) & Micro-Nano Technology (MNT) Fabrication 2018/19 -

- **186** multi-project wafer (MPW) designs were fabricated in **25** services (see Appendix B) available through partnerships with international foundries: Advanced Micro Foundry (AMF) (Singapore), AMS AG (Austria), GlobalFoundries (USA), MEMSCAP (USA), Micralyne (Canada), STMicroelectronics (France), TSMC - Taiwan Semiconductor Manufacturing Company (Taiwan), and Teledyne DALSA (Canada)

Five-year Period

- More than **1700** designs progressed to fabrication (2014/15 through 2018/19)
  - 35% microelectronics
  - 25% photonics or optoelectronics
  - 22% MEMS
  - 18% nano, bipolar, microfluidics, or special packaging

Photonics

- By March 2019, over **800** photonics & optoelectronics designs progressed to fabrication for prototype purposes through CMC (2008/09 through 2018/19) – it includes 670 MPW designs, 100 MNT designs, and 38 commercial projects.
  - **580** designs were silicon photonics (includes fabrication training program projects)
  - **115** designs were III-V technology

CNDN Technology Roadmap

In June 2018, following extensive stakeholder consultations, CMC released an update to the CNDN Technology Roadmap. It included several important signals about CNDN technology direction, including:

- The emergence of AI and machine learning as a significant computing workload and a prime force for driving new technologies, architectures, and methods.
- Increased emphasis on photonic-microelectronics integration technologies, silicon germanium (SiGe) and CMOS-opto technologies (single-photon sensitive detectors).
- Support for quantum research at the intersection of photonics, microelectronics, nanofabrication, and packaging technologies.
- An opportunity to advance the state of quantum engineering and related R&D through delivery of new CAD/TCAD tool options.
- Reinforced need for more hands-on training, for example, in advanced microelectronic technology design including FinFET layout.

FAB Capabilities added in 2018/19

CMC partnered with:

- **Advanced Micro Foundry (AMF)** to develop an unprecedented design automation platform for silicon photonics with a value-add physical design kit (PDK).
- **3IT.Nano** (Université de Sherbrooke) for fabrication of open-gate silicon junction field effect transistors.
- **Micralyne (now Teledyne Micralyne)** to develop a solution to manufacture interposer-based modules incorporating semiconductor wafers with Through Silicon Vias (TSVs).

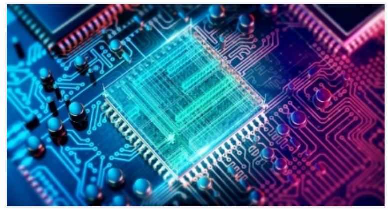
Industry Program: SponsorChip

- CMC introduced a program where companies can choose a chip fabrication technology and topic area of interest and CMC helps to identify potential future partners, explore topics in the design and manufacturing space, submit designs alongside those of the students - contribute to grad student skill development in your companies area of interest - and benefit from CMC know-how. See more in Appendix C.

Looking for Collaborative Opportunities?

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

www.cmc.ca/FAB



Contents

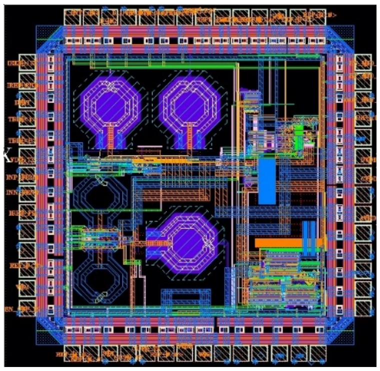
MICRO-NANOELECTRONICS

Technology: 28-nanometer CMOS

ST CMOS 28nm FDSOI

80 Gb/s PAM-4 Receiver Utilizing Sub-range Flash ADC and TDC

Applications include: ICT



A 80 Gb/s low power PAM-4 receiver based-on sub-range Flash Analog-to-Digital Converter (ADC) and Time-to-Digital Converter (TDC). The target power budget is 50% lower than the state of the art of the high-speed PAM-4 receiver.

University of Alberta
Designer: . Aurangozeb | aurangoz@ualberta.ca
Professor: Masum Hossain | masum@ualberta.ca

ST CMOS 28nm FDSOI

Radiation Effects Studying on PLLs using FDSOI 28nm Technology

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

PLLs have been widely used in different applications, such as the frequency synthesis, clock recovery circuits, local oscillator (LO) frequency generators, etc. The main function of the PLL is focused on producing an output signal at a specific frequency. A basic PLL comprises a phase detector, charge pump, loop filter, a voltage-controlled oscillator and a fractional divider. In 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. In this project, different sensitive sub-circuits of the PLL will be designed and tested separately to investigate the radiation sensitivity of each one, considering the charge pump is one of the most sensitive components of the PLL to single events, a radiation-hardened charge pump will be proposed in this project to analysis the anti-radiation effectiveness. If the CP is hardened to a sufficient level, the VCO becomes the dominant SE upset source, mainly because the VCO has the greatest cross-section, which indicate that the majority of the single event transients (SETs) generated in the PLL will be due to strikes in the VCO. RO (ring oscillator) has a wider range of operation, simple structure and smaller circuit area, therefore a current starved RO and a CML RO will be fabricated separately for the radiation effects analysis. Finally, a fully integrated radiation hardened PLL in FDSOI 28nm process will be implemented for radiation analysis.

University of Saskatchewan
Designer: Jaime Cardenas | jsc494@mail.usask.ca
Professor: Li Chen | li.chen@usask.ca

Technology: 65-nanometer CMOS

TSMC 65nm CMOS

77GHz DCO for Automotive Radar

Applications include: Automotive

A design of 77GHz Colpitts-Clapp DCO that addresses Short Range Radar (SRR) requirements for automotive radar. Automotive SRR contributes to road safety via pre-crash sensing, blind-spot detection, and collision avoidance. DCO for automotive SRR requires low Phase Noise (PN) and wide Tuning Range (TR). Range resolution is a key requirement of the FMCW SRR that depends on the transmitter bandwidth (B) and hence the local oscillator TR. The 77GHz SRR operates in the range of 77-81GHz and requires a bandwidth of 4GHz in order to enable the range resolution requirement. For such a wide frequency range, amplitude-to-phase conversion needs to be avoided. Besides, the local oscillator amplitude is significantly related to the SRR transmitter power that can affect the high limit requirement (EIRP restriction). Achieving low PN and wide TR simultaneously is challenging at mm-wave DCOs. Based on an in-depth mathematical analysis, a negatively boosted structure is employed in this design, which increases the amplitude without the need to increase the biasing current, and stabilizes the amplitude across the wide TR. Moreover, it relaxes the restriction on the value of the transconductance that is required to start up the DCO. The effectiveness of the modified topology in increasing and stabilizing the amplitude across the TR and boosting the oscillation initiation are validated through simulation, and the expected mathematical results are verified. Pnoise setup with SpectreRF is used to simulate the PN. Simulation results for the DCO show that, even with 10% reduction in the power consumption, the amplitude of oscillation for the modified DCO is boosted by 36%. The amplitude varies by just 2.4% across the TR as compared to 16.7% variation before modification. Start-up time is reduced by 47% and the PN is 3 dB better.

University of Windsor
Designer: Iman Taha | taha@uwindsor.ca
Professor: Mitra Mirhassani | mitramir@uwindsor.ca

TSMC 65nm CMOS

8-Channel TDC for Diffuse Optical Tomography

Applications include: Health/Biomedical

The Groupe de Recherche en Appareillage Médical de Sherbrooke (GRAMS) is working on electronic instrumentation and detectors for new generations of medical imaging systems, specifically positron emission tomography (PET) and diffuse optical tomography (DOT). These medical imaging methods benefit from ultra-precise time-of-flight (ToF) measurement in order to achieve higher spatial resolution and better contrast of the image. Current DOT scanners suffer from excessively low sensitivity caused by the small number of detectors. The GRAMS is currently focusing on integrating more channels inside the detector ring using custom-designed single photon avalanche diode (SPAD) detectors, high-density time-to-digital converters (TDC) and custom silicon/glass interposer. We propose an 8-channel TDC ASIC, implemented in 65 nm technology, dedicated to multi-channel ToF measurement for DOT scanner and fluorescence lifetime imaging (FLIM). This project aims at reducing the overall cost of DOT scanners by replacing the existing commercial acquisition system with a low-cost solution with competitive performance and greater pixel density while drastically reducing the power consumption of the system. This TDC design is based on three ASIC revisions developed in 65 nm: the 1st and 2nd revisions were test circuit to characterize and optimize the TDC architecture and its characteristics, while the third revision was an array of 256 TDCs design for a 3D integrated detector for PET imaging. Objectives: (1) Develop an 8-channel TDC ASIC with a 200 ns dynamic range including individual LVDS input and output, calibrated with a phase locked loop (PLL) and dedicated to reverse start/stop measurements. (2) Develop a data extraction circuit to optimize throughput of all converters and send raw timestamps to a FPGA-based platform. (3) Optimize power consumption throughout the circuit.

Université de Sherbrooke
Designer: Frédéric Nolet | frederic.nolet@usherbrooke.ca
Professor: Jean-François Pratte | jean-francois.pratte@usherbrooke.ca

TSMC 65nm CMOS

A Low-Phase-Error Wideband 360-Degree Phase Shifter Suitable for 5G Applications

Applications include: ICT

This design is one of the main blocks of a highly linear and efficient power amplifier for 5G applications. As a critical building block of the proposed phase shifter, we focus on the design of a quadrature poly-phase all-pass filter (QPAF) and its biasing stages to generate the quadrature signal with a very low phase error over a wide bandwidth and change the output phase shifter in an analogue manner, respectively. All the mathematical analyses of QPAF have been completed and the results are submitted to IEEE Transactions on Circuits and Systems I.

University of British Columbia
Designer: Alireza Asoodeh | asoodeh@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 65nm CMOS

A New Difference Time to Digital Converter Based on Cyclic Structure for Low Frequency Applications

Applications include: Health/Biomedical

This Project concerns a new cyclic time-to-digital converter (TDC) with measuring the difference between consecutive input samples. The TDC proposed based on digital-to-time converter (DTC) and counter block is suitable for low varying inputs such as biological signals. The TDC shows power-efficient performance compared to the recent work in the literature for low frequency applications. In this proposal, the target is design and implement a time-based readout circuit for portable device in the biomedical applications.

Polytechnique Montréal
Designer: Mohammad Saleh Rostami | saleh.rostami@polymtl.ca
Professor: Mohamad Sawan | mohamad.sawan@polymtl.ca

TSMC 65nm CMOS

Designing High Order OTAs Using the Concept of Pole-Zero Pair Positioning

Applications include: ICT (electronics engineering, video and audio applications)

This project presents a new concept for designing high order OTAs using Pole - Zero pair positioning. With this concept the stability of the OTA is ensured with the proper positioning of the Pole - Zero pairs, which allows the cascading of high gain stages. The goal of these high gain stages is to increase the robustness of the design and to drive a range of different loads.

McGill University
Designer: Mahmood Mohammed | mahmood.mohammed@mail.mcgill.ca
Professor: Gordon Roberts | gordon.roberts@mcgill.ca

TSMC 65nm CMOS

Battery-less SoC for IoT Applications

Applications include: ICT

In this project, we design and test a battery-less system-on-chip (SoC) for Internet of Things (IoT) applications. This research is in collaboration with EPIC Semiconductor and is based on their nano-cloud processor (nCP) architecture. The system harvest energy from electric field and consists of a proprietary energy harvesting circuit, and ultra-low-power building blocks including an analog interface circuit, an analog to digital converter (ADC), an Inter-Integrated Circuit (I2C) bus, and a digital processing core.

University of British Columbia
Designer: Mohammad Beikahmadi | beikahma@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 65nm CMOS

Dual Split Capacitor SAR ADC with All Digital Radix Calibration

Applications include: ICT (consumer electronics)

This project focuses on a dual split capacitor array digital-to-analog converter (DAC) architecture with two bridge capacitors for successive approximation register analog-to-digital converters (SAR-ADC). This architecture provides significant area savings and has a much smaller input capacitance than traditional binary weighted (BW) DACs. Having one bridge capacitor divides the BW-DAC into the conventional split capacitor DAC architecture, which can reduce the overall area of the SAR-ADC by approximately half. This can be further reduced by adding even more bridge capacitors, which gives rise to the C-2C DAC architecture. However, due to the size of the unit capacitors, the C-2C DAC architecture is extremely sensitive to parasitic capacitance, which causes considerable degradation to its performance and signal to noise and distortion ratio (SNDR). The primary objective of this project is to highlight the performance of the dual split capacitor DAC over its counterparts. Also, an all-digital radix calibration, which uses a least mean square (LMS) adaption algorithm, is implemented to correct for static nonlinearities created by the parasitic capacitance in the DAC. This highlights the effectiveness of digital calibration algorithms and assesses the extent of the errors the algorithm is capable of correcting.

University of Toronto
Designer: Paul Chen | paul.chen@isl.utoronto.ca
Professor: Anthony Chan Carusone | tcc@eecg.utoronto.ca

TSMC 65nm CMOS

Compact Vector Modulator Network for 5G Beamsteering in Mobile Devices

Applications include: Automotive, ICT

The design is a compact vector modulator network based on a vector-sum phase shifter (VSPS). In order to implement vector modulators at each of the antennas in an array within mobile devices, redundant structures (namely the fixed phase shifters within each VSPS) need to be reused. This design would make beamsteering in 5G devices a possibility since it addresses the issue of limited space. Specific to the IC design being submitted, it will consist of 4 input ports and one output port (which will combine the vector modulated signals of the 4 inputs). The IC will operate at a band centered around 28GHz (a proposed band for 5G mobile communication). The signals on the four inputs can be individually controlled.

University of Alberta
Designer: Khaled Al-Amoodi | kalamood@ualberta.ca
Professor: Duncan Elliott | duncan.elliott@ualberta.ca

TSMC 65nm CMOS

Extremely Fine Resolution Sub-Ranging Current Mode DAC using Sigma-Delta Encoded Bit-Streams

Applications include: ICT (electronics engineering: audio players, video players, display electronics, cellular telephones, Automatic Test Equipment (ATE), pressure sensors and motor speed control)

In this project, a novel, high-resolution, simple to implement DAC is to be implemented. The proposed DAC design is based on sub-ranging and segmentation using encoded Sigma-Delta bit-streams. This design would be very useful in applications where DACs are used for Calibration and test. The proposed designed would provide almost 25% area and power savings compared to conventional designs.

McGill University
Designer: Ahmed Emara | ahmed.emara@mail.mcgill.ca
Professor: Gordon Roberts | gordon.roberts@mcgill.ca

TSMC 65nm CMOS

Full-Duplex Self Interference Cancellation RX

Applications include: ICT

A compact, tunable and fully monolithic prototype for self interference cancellation in Full-duplex radios is proposed. > 35 dB of cancellation over a broadband 80 MHz BW (largest-ever-reported) is the designated goal for this project, using multiple taps of Hilbert Transformation.

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

TSMC 65nm CMOS

High-frequency VCO with Injection-locked-based Programmable Divider and Multi-Phase Outputs

Applications include: ICT

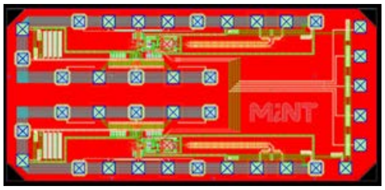
This design consists of VCO that has a center frequency of 20G with a tuning range of 25 percent. Also, it has a programmable injection locked frequency divider with high division ratios of 5 or 8. Hence the 20G signal can be brought to a much lower frequency. The design is optimized for noise and power.

University of British Columbia
Designer: Lakshmi Lavanya Bodepu | lavanyab@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 65nm CMOS

High Linearity 5GS/s Voltage-to-Time Converter

Applications include: Aerospace, ICT



This chip implements a high-linearity differential voltage-to-time converter (VTC) designed for use in time-based ADC architectures. While conventional VTCs based on starved-inverter topologies produce a delay by varying the slope of voltage ramps, this VTC design uses a novel "constant-slope charging" technique which is inherently more linear. The VTC is primarily designed for 5GS/s sampling rate with 50ps peak-to-peak differential delay (tunable), but it can be operated at 3GS/s to 7GS/s. Simulation results show that the VTC achieves a broad input bandwidth with ERBW more than the Nyquist rate. At 5GS/s with 50ps differential delay, the VTC core consumes 3.7 mW from a 1.0 V supply and achieves a DNL and INL of 0.027LSB and 0.100LSB, respectively. The ENOB remains above 8.0 bits (49.92dB SINAD) for input frequencies up to the 5GHz sampling rate itself. The size of the chip is based on the number of required bond-pads. These results show that the VTC design is well-suited for high speed time-based ADC applications, which in our case is the Square Kilometer Array (SKA).

University of Calgary
Designer: Dhruv Bhaskar | dbhaskar@ucalgary.ca
Professor: Leonid Belostotski | lbelosto@ucalgary.ca

TSMC 65nm CMOS

High-speed Low-power PAM4 DFE

Applications include: ICT

In this design a high-speed low-power PAM decision feedback equalization (DFE) system will be implemented. Based on the theoretical modeling and Cadence simulation, we believe the design could offer superior performance compared to state of the art.

University of British Columbia
Designer: Yang Wang | yangwang@ece.ubc.ca
Professor: Sudip Shekhar | sudip@ece.ubc.ca

TSMC 65nm CMOS

High Voltage Ultra Wideband Pulse Generator

Applications include: Automotive, ICT, Health/Biomedical

In this project, we will design and fabricate ultra-wideband (UWB) pulse generator capable of generating high output voltage pulse under the FCC mask requirements. The proposed UWB pulse generator can be used in transmitter part of wideband radar, wireless sensor applications and so on. With an ultra-wide bandwidth, the radar system can achieve a very high resolution. The ability to generate high peak to peak voltage or high peak power relieve the limitation of the low output swing when implemented in CMOS technology with low supply voltage.

University of Alberta
Designer: Shengkai Gao | shengkai@ualberta.ca
Professor: Kambiz Moez | kambiz@ece.ualberta.ca

TSMC 65nm CMOS

Hybrid Voltage and Time Mode Analog to Digital converter

Applications include: Health/Biomedical, ICT

A continuous-time Delta Sigma modulator with embedded time-based quantization is proposed. The proposed Delta Sigma modulator consists of the cascade connection of a front-end multi-bit continuous-time Delta Sigma modulator and a back-end time-to digital converter made up of a pulse width modulator and a gated ring oscillator. This time-to-digital converter is also used as the embedded quantizer in the front-end stage, with the subsequent benefits in terms of increased noise-shaping, inherent linearity of the feedback digital-to-analog converter and time-encoded digital implementation of the inter-stage path. These features make the proposed Delta Sigma modulator a scaling-friendly approach for the implementation of high-speed analog-to-digital converters with reduced analog circuitry.

Polytechnique Montréal
Designer: Mohammad Honarparvar | mohammad.honarparvar@polymtl.ca
Professor: Mohamad Sawan | mohamad.sawan@polymtl.ca

TSMC 65nm CMOS

Injection Locked 8PSK Transmitter

Applications include: Health/Biomedical, ICT

This chip is an 8PSK transmitter, generating 8 different--on demand--phases at the output. With the aid of a novel open loop structure, this design yields a larger modulation bandwidth compared to closed loop architectures and consumers less power. Biased in class C, this injection locked oscillator integrated with a PA, is expected to be more efficient compared to the state of the art.

University of Toronto
Designer: Saba Zargham | saba.zargham@mail.utoronto.ca
Professor: Antonio Liscidini | antonio.liscidini@utoronto.ca

TSMC 65nm CMOS

Low-Voltage Low-Power Quadrature VCO

Applications include: ICT

The main objective of this work is to design and implement a low-voltage low-power dual band quadrature voltage-controlled oscillator (QVCO). Based on the preliminary analysis and simulations, the system would be able to operate from a 0.4 V supply and consume ~300 uW and ~960 uW at 2.4GHz and 5GHz, respectively.

University of British Columbia
Designer: Maggie Yu | maggieyu@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 65nm CMOS

MEMS Oscillator Circuit

Applications include: ICT (electronics engineering: systems, cellular phones, computers)
The design objective is to create low phase noise, frequency-adjustable timing references at low cost. It introduces the concept of an ultra-low power oscillator based on MEMS resonators for timing references. This project is investigating the development of the two components of this timing references: (1) electronic Trans-Impedance amplifier for the MEMS resonator, and (2) the phase-lock loop to control the precise oscillation frequency.

McGill University
Designer: Ahmed Kira | ahmed.kira@mail.mcgill.ca
Professor: Gordon Roberts | gordon.roberts@mcgill.ca

TSMC 65nm CMOS

Mixed Signal Implementation of MAC Unit

Applications include: ICT

This work introduces a low-power, high-speed area-efficient multiplier-accumulator (MAC) unit scheme that are essential for convolutional neural network (CNN) implementation in machine learning hardware. The MAC unit is bench marked in finite impulse response (FIR) and discrete cosine transform (DCT) implementation that shows 2.5X to 3X performance and speed improvement compared to traditional digital implementation.

University of Alberta
Designer: Aurangozeb . | aurangoz@ualberta.ca
Professor: Masum Hossain | masum@ualberta.ca

TSMC 65nm CMOS

Neural Amplifier

Applications include: Health/Biomedical

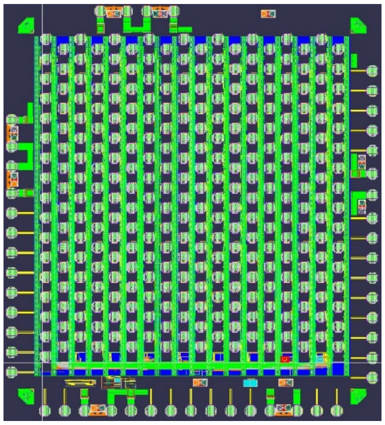
A neural amplifier with variable gain between 800 up to 1200 is proposed. By using a novel contribution, the low-cut-off frequency of this amplifier deceased to less than 1Hz. This amplifier has been designed in 3 stages to obtain the mentioned gain while the last stage is a Variable Gain Amplifier (VGA). It is designed to have bandwidth between 1Hz and 5 KHz for neural recording implant application. For this purpose, it is low power and compact.

Polytechnique Montréal
Designer: Fereidoon Hashemi Noshahr | fereidoon.hashemi@polymtl.ca
Professor: Mohamad Sawan | mohamad.sawan@polymtl.ca

TSMC 65nm CMOS

Neurostimulator Chip for Ocular Prosthesis

Applications include: Health/Biomedical



This project aims to design the electronics of an ocular prosthesis with goal to restore partial vision to blind people and help them regain autonomy. This prosthesis consists of a neurostimulator ASIC encapsulated in a diamond package with its ancillary electronics, implanted into the eye bulb. The external parts included a CCD camera held on glasses, a laser and video processing unit (VPU). The image acquired by the camera is processed by the VPU, important feature of the image are extracted and send to the neurostimulator ASIC that will stimulate the retina through an electrode array. More specifically, the neurostimulator ASIC consists of 288 electrodes drivers in a staggered pattern and receive data wirelessly from an external processor via an optical link and an RF link for reversed data. Each electrode driver is fully programmable to stimulate the retina with a biphasic stimulating current ranging from 0 uA to 255 uA with a 1 uA precision. The stimulator is a mixed-signal design that includes an embedded digital controller managing the communication protocol with the external processor and the stimulating sequence of the electrodes based on high acuity current steering and current focusing stimulation algorithms.

Université de Sherbrooke
Designer: Konin Koua | konin.calliste.koua@usherbrooke.ca
Professor: Réjean Fontaine | rejean.fontaine@usherbrooke.ca

TSMC 65nm CMOS

Non-Interleaved 10GS/s 7-Bit ADC

Applications include: Aerospace, ICT

In the 1302CS run, we successfully demonstrated a single-channel 10GS/s 4-bit ADC with digital background calibration (ICSCYYS6). Measurements show that at 10GS/s, the prototype ADC achieves an SNDR of 24.9 dB (3.84 ENOB), and 23.4 dB (3.59 ENOB), at low input frequency and Nyquist, respectively. The chip consumes 104 mW from a 1.3 V power supply. This project is to increase the number of bits in the ADC to 7 bits but reusing the 4-bit ADC and supplementing it with a novel 3-bit sub-ranging circuit capable of operating at 10GS/s. The ADC will also incorporate a 10GS/s track and hold circuit previously verified in 1502CS (design ICSCYTH1). The ADC will have 7 differential outputs which incorporate a novel scrambled cyclic redundancy check (CRC) for error detection and multi-lane 10GS/s data synchronization. The ADC outputs will be directly acquired by any platform with clock data recovery (CDR) capability based on Xilinx 7 series FGPA. This will enable the ADC to be completely ready to apply to applications such as Software Defined Radio (SDR) and RF direct-sampling receiver systems, in our case, the Square Kilometre Array (SKA).

University of Calgary
Designer: Eugene Zailer | ezailer@ucalgary.ca
Professor: Leonid Belostotski | lbelosto@ucalgary.ca

TSMC 65nm CMOS

Novel CMOS SPADs for New and Existing Biomedical Application

Applications include: Health/Biomedical, ICT

Current research on single photon avalanche diodes (SPADs) are focused around deep-submicron (DSM) technologies in order to efficiently reduce the cost and size of the sensor and allow for easy scalability and integration with digital signal processing circuits. Along with improvements in diffuse optical tomography (DOT), we see the potential for alternative, low-cost, and portable devices to improve current medical imaging, monitoring and diagnostic techniques. To achieve this, our primary objectives are:

- The design and test of novel SPAD designs in standard CMOS technology with a focus on optimizing performance for brain imaging and blood oxygen monitoring.
- To investigate the differences between technologies on the performance of SPADs
- To characterize defects and develop physical models to accurately important performance parameters of SPADS such as charge transfer, after-pulsing, dark current, and associated time constants. These will be the first models to predict such performance measures and are essential for designing improved SPAD-based imaging systems.

McMaster University
Designer: Yamn Chalich | chalichy@mcmaster.ca
Professor: Jamal Deen | jamal@mcmaster.ca

TSMC 65nm CMOS

Novel Neuromorphic SRAM Synapses / Sense Amplifier Array / Sense Amplifiers for STT-RAM

Applications include: ICT (and other)

Neuromorphic computing is a rapidly developing field with few commercial products currently available. The applications are broad, and anything that currently benefits from deep learning algorithms would further benefit from neuromorphic computing. STT-RAM is an emerging non-volatile memory that can find potential applications as embedded low power cache memories. Our test chip would allow us to test new sense amplifier circuits. Thus, the proposed designs find potential applications in embedded application. This test chip will have three subsystems:

1) A new SRAM-based neuromorphic synapse circuit that uses a new decoder architecture in place of exotic memristive elements
2) An SRAM array working around 150 mV of supply voltage for mobile applications
3) Variants of the sense amplifiers for Spin Transfer Torque-Random Access Memories (STT-RAMs).

University of Waterloo
Designer: Govindakrishnan Radhakrishnan | gradhakr@uwaterloo.ca (now Radhakrishnan@cmc.ca)
Professor: Manoj Sachdev | msachdev@uwaterloo.ca

TSMC 65nm CMOS

pH Sensitive Field Effect Transistor

Applications include: Environment

We want to fabricate a pH sensitive field effect transistor. The FET is being designed in Cadence and will be fabricated using TSMC 65 nm standard GP CMOS Process.

McGill University
Designer: Gueorgui Savadjiev | gueorgui.savadjiev@mail.mcgill.ca
Professor: Sharmistha Bhadra | sharmistha.bhadra@mcgill.ca

TSMC 65nm CMOS

Phased Array Transmitter for Wireless Power Charging

Applications include: ICT

High-Power Transmitter to be used for wireless charging, with phase shifters introduced to enable beamforming.

University of British Columbia
Designer: Avilash Mukherjee | avilash@ece.ubc.ca
Professor: Sudip Shekhar | sudip@ece.ubc.ca

TSMC 65nm CMOS

Probabilistic-based Complementary Logic Stochastic Discrete Cosine Transform Design

Applications include: Health/Biomedical

Markov Random Field (MRF) theory has been applied in lots of noise-tolerant digital circuit designs. However, large area overhead deriving from its complexity, which is at least 6 times the area of the corresponding traditional circuit, is the undeniable trade-off for its high noise immunity. Conversely, the remarkable advantage of Stochastic Computing (SC), a simple form of number representation, is its low hardware cost. We found out the characteristic of the asymmetric output distribution of an asymmetric logic gate such as a NAND gate. By using asymmetric logic gates, we can build probabilistic-based complementary logic gates which has robust output signals under the presence of noise. Compared with traditional MRF gates, it requires less hardware cost and has good noise-immunity. Considering the above properties of probabilistic-based complementary logic gates and SC circuit, it is a win-win situation when there is a combination of the two techniques. Therefore, we propose the probabilistic-based complementary logic design for stochastic one-dimensional discrete cosine transform (1D-DCT). It saves more hardware cost than previous MRF-based SC DCT. The main attraction of the proposed design is its low power and hardware cost with high noise immunity compared with traditional DCT computation circuits. It can be applied on outdoor sensors and biological portable devices which require low power consumption and high reliability to tolerate the environmental noise.

University of Alberta
Designer: Yufeng Li | yufeng3@ualberta.ca
Professor: Jie Chen | jchen@ece.ualberta.ca

TSMC 65nm CMOS

RF Energy Harvester with Adaptive Voltage Limiter

Applications include: Environment, ICT, Natural Resource/Energy

In this project, an efficient radio frequency (RF) energy harvester will be designed and fabricated. RF energy harvester can be used to charge battery-based wireless IoT sensors. An efficient single-stage rectifier will be used to charge a 1V to 3V battery by using an adaptive threshold cancelation scheme. Charging the battery of wireless sensors using RF energy harvesting can increase their lifetime and so make using a large scale of these sensors possible. In this design, another circuit for limiting the output voltage of harvester according to the battery specification will be designed. The designed circuit will limit the output voltage of the rectifier by external resistors to not damage the battery.

University of Alberta
Designer: Mohammadamin Karami | mkarami@ualberta.ca
Professor: Kambiz Moez | Kambiz@ece.ualberta.ca

TSMC 65nm CMOS

RF Transmitter Chip for Ocular Prosthesis

Applications include: Health/Biomedical

This project aims to design an RF transmitter chip that will be embedded in an ocular prosthesis with the goal of restoring partial vision to blind people and help them regain autonomy. The prosthesis consists of a neurostimulator ASIC encapsulated in a diamond package with its ancillary electronics, implanted into the eye bulb. The external parts include a CCD camera held on glasses, a laser and video processing unit (VPU). The image acquired by the camera is processed by the VPU, important features of the image are extracted and sent to the neurostimulator ASIC that will stimulate the retina through an electrode array. More specifically, the neurostimulator ASIC receives data wirelessly from an external processor via an optical link and sends out status messages and monitoring data through an RF transmitter. For packaging integration, a custom bare die RF transmitter with maximal dimensions of 1 x 1 mm2 and power consumption below 1 mW is required. This transmitter consists in a 2.4 GHz oscillator that delivers data stream with OOK modulation at 1Mbps. The transmission frequency and power can be tuned using digital control signals.

Université de Sherbrooke
Designer: Maher Benhouria | maher.benhouria@usherbrooke.ca
Professor: Réjean Fontaine | rejean.fontaine@usherbrooke.ca

TSMC 65nm CMOS

Switched-Capacitor DAC Transmitter

Applications include: ICT (wireless communications)

A digital wireless transmitter (TX) suitable for multi-standard operation is implemented using a passive switched capacitor topology. The design does not require any active circuitry, such as OTAs or transconductors, for digital to analog conversion, baseband filtering, and upconversion resulting in a CMOS scaling-friendly architecture. Thanks to passive switched capacitors, the design is modular and the filter order scalable. Baseband bandwidth can be reconfigured to server various wireless standards and reduces out-of-band emissions. This transmitter is an incremental upgrade of a previous design idea and uses higher resolution DACs to minimize quantization noise and introduces a wider bandwidth tuning range and power control in the output driver amplifier (DA) and an SPI controller for easier configuration of the operating mode.

University of Toronto
Designer: Konstantinos Vasilakopoulos | k.vasilakopoulos@mail.utoronto.ca
Professor: Antonio Liscidini | antonio.liscidini@utoronto.ca

TSMC 65nm CMOS

Time to Digital Converter (TDC)

Applications include: ICT (consumer electronics)

This project focuses on design of a multi-channel time to digital converter (TDC) for time of flight Lidar applications. The proposed architecture employs sharing schemes to provide significant area, and power savings.

University of Toronto
Designer: Foad Arvani | foad.arvani@mail.utoronto.ca
Professor: Anthony Chan Carusone | tcc@eecg.utoronto.ca

TSMC 65nm CMOS

Transimpedance Amplifier for MEMS-Based Oscillators

Areas of application include: ICT

The proposed design is the second version of the transimpedance amplifier (TIA) for MEMS-based oscillators previously fabricated. In this project, the goal is to improve the CMOS circuit required to sustain oscillation with a MEMS resonator such that high linearity and phase-noise performances are attained. The TIA can provide a high gain-bandwidth product with an adjustable bandwidth to offset the resonator losses and to ensure a small phase shift so that high oscillation frequencies (larger than 20 MHz) can be attained. Furthermore, improved input and output impedance reduction methods are applied to avoid loading the resonator's quality factor at a low power-consumption cost.

Université du Québec à Montréal
Designer: Anoir Bouchami | bouchami.anoir@courrier.uqam.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

TSMC 65nm CMOS

Transition Dependent Driver and Receiver

Applications include: ICT

It is a transition dependent driver which compensates the transition rate by avoiding transitions when bit information doesn't change. It groups two to three bits together for transmitting, while conventional ones make a transition for each bit of information. It doesn't burn any power while bit information doesn't change. Thus, saving more power than the traditional transmitters. The receiver is designed using only two comparators and the decoding logic.

University of Alberta
Designer: Shovon Dey | sdey@ualberta.ca
Professor: Masum Hossain | masum@ualberta.ca

TSMC 65nm CMOS

Ultra Low Power Multi-Band Radio Frequency Energy Harvesting Interface for Wearable Devices

Applications include: Health/Biomedical, Natural Resource/Energy

An ultra low power and fully integrated RF energy harvesting system, in 65 nm CMOS technology is presented. The system uses ISM bands (915 MHz and 1850 MHz) and Wi-Fi (2.4 GHz and 5 GHz) as inputs with sensitivity of 30 dBm. We demonstrate a new RF-DC power converter with both dynamic and static self compensating schemes to reduce the threshold voltage of rectifying devices. The proposed scheme overcomes challenges for achieving high power conversion efficiency (PCE) at ultra-low input power. Moreover, a power management unit (PMU) is designed as interface between transducer and load to combine powers, match voltage and current of the RF front end and load. It also minimizes the power consumption.

Polytechnique Montréal
Designer: Seyed Mohammad Noghabaei | seyed-mohammad.noghabaei@polymtl.ca
Professor: Mohamad Sawan | mohamad.sawan@polymtl.ca

TSMC 65nm CMOS

Underwater Communication Transceiver

Applications include: Automotive, Environment, Defence (Safety, Security), Natural Resource/Energy

A fully integrated acoustic-to-RF relay transceiver will be developed to enable low-power communication devices for underwater sensing. The fully analog design will also include adaptive filters for N-paths channel selection. The direct conversion technique will be employed. These efforts present promising results, yet, in order to meet a required litetime spanning multiple years, the circuit complexity must be reduced significantly without compromising the link reliability. In this design, we employ the zero IF frequency technique and high-efficient VCO to reduce the DC power consumption as the life cycle is much important to underwater equipment.

Dalhousie University
Designer: Ningcheng Gaoding | ningcheng.gaoding@dal.ca
Professor: Jean-Francois Bousquet | jbousquet@dal.ca

TSMC 65nm CMOS

Wide Band mm wave Injection locked Frequency Divider (by 2)

Applications include: ICT

This design consists of free running LC-VCO (Divider) that has a center frequency of 20GHz. An external input signal of the range 20GHz to 60GHz is applied as the injection signal with frequency (Finj). The VCO is expected to lock at the frequency of Finj/2 which falls in the range of its free running frequency. The Injection Locked Frequency Divider (ILFD) is expected to operate at less than 3mW. Also, the ILFD operates at low voltage supplies.

University of British Columbia
Designer: Lakshmi Lavanya Bodepu | lavanyab@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 65nm CMOS

Wide Tuning Range VCO for mm-wave Applications

Applications include: Automotive, Agriculture/Agri-Food

The objective of my Ph.D. research project is to develop low-cost phased array transceivers in standard CMOS technology. CMOS technology offers the lowest implementation cost for complex phased-array systems as it offers the higher integration level and lowest fabrication costs. Phased-array systems are needed for next generation (5G and beyond) millimeter-wave (mm-wave) and sub-THz wireless communication systems to compensate for path losses at these frequencies and for improving the resolution of microwave imaging devices operating in these frequencies. We plan to address challenges of design at such high frequencies by introducing novel circuit and system techniques in this research. Voltage-controlled oscillator (VCO) is a major building block of any mm-wave transceiver and high tuning range VCO is really desired for mm-wave applications. In low frequencies, a parallel combination of high Q switched capacitors and MOS varactors are used as an ordinary solution for large tuning range and low Phase-Noise (PN) VCOs design where the employed switched capacitors and varactors are for high-discrete and fine frequency tuning, respectively. However, in mm-wave frequencies, LC-tank Q is drastically low when the switches are directly conducted in series with the capacitors and Inductors. Hence, to achieve a proper oscillation with the low frequency methods, size of the transistors should be increased to compensate the loss of LC-tank; As a result, in addition to the higher power dissipation, fixed parasitic capacitance will be increased which limits the maximum oscillation frequency and tuning range of VCO. Consequently, high power and coarse tuning range, mm-wave VCO design, is very challenging in presence of internal/external device parasitics and LC tank loss. In this project, we will design and fabricate two novel multiband wide tuning range (WTR) fundamental harmonic VCOs in 65nm CMOS technology for millimeter wave (mm-wave) applications.

University of Alberta
Designer: Ali Basaligheh | ali.basaligheh@ualberta.ca
Professor: Kambiz Moez | kambiz@ece.ualberta.ca

TSMC 65nm CMOS

Wideband Allpass Filters and Their Applications

Applications include: ICT

In this project, a new second-order allpass filter topology has been proposed and is to be verified experimentally. The advantage of the proposed topology is its ability to provide a large controllable group delay over a multi-GHz frequency range with a high delay-bandwidth product (DBW). The proposed allpass filter has a voltage mode operation and a low output impedance. These allow for easy cascading of the proposed allpass circuits. Most other CMOS allpass filters employ operational current and voltage amplifiers, which are bandwidth limited by parasitics at high impedance nodes, thus limiting their application domain to low frequencies. The primary application of the proposed allpass filter is the 5G communication links beamforming. The targeted frequency band is 28GHz. The proposed allpass filter is designed to provide a minimum group delay of 4.24ps based on the Nyquist spacing at the frequency of operation. The power consumption of the proposed allpass filter is 14mW.

University of Calgary
Designer: Mohamed Mohamed | mohamed.elamienmoham@ucalgary.ca
Professor: Brent Maundy | bmaundy@ucalgary.ca

TSMC 65nm CMOS

Wirelessly Powered Closed-loop Neurostimulator System-on-Chip with EDM Brain State Classifier

Applications include: Health/Biomedical

This design implements a system-on-chip that features a closed-loop stimulator along with a built-in machine learning accelerator for the classification of complex temporal patterns in human brain dynamics, with the use of exponentially decaying memories (EDMs). The system is wirelessly powered by employing a custom laid-out on-chip inductor as a power receiver. We propose a design strategy that optimally confines the electric field on the surface of the chip, extending the range of maximum received power available under FDA approved standards. A signal processing analog front-end is comprised by sub-µW voltage & current recording channels, in addition to a biphasic programmable current stimulator. Recent developments have demonstrated the suitability of random classifiers to brain state classification including the winning entry in the widely recognized Kaggle seizure prediction challenge. While random forests are generally computationally complex in terms of on-chip memory requirements, we have identified architectural innovations that could be the missing link to lend their utility to low-power implantable and wearable technology. Such approach also helps to reduce the payload of the data telemetry, also implemented in the system for diagnosis purposes, since already-processed markers can be transmitted instead of entire waveform information. The codesign of the aforementioned blocks in a complete fully wirelessly powered system-on-chip could lead to breakthrough applications in closed-loop neurostimulation implantable devices for the treatment of neurological disorders such as epilepsy and Parkinson's disease.

University of Toronto
Designer: Jose Batista de Sales Filho | jose@ece.utoronto.ca
Professor: Roman Genov | roman@eecg.utoronto.ca

Technology: 130-nanometer CMOS

TSMC 0.13µm CMOS

3rd Generation DNA Sequencing Mixed-Signal CMOS Readout Chip

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

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.

York University
Professor: Sebastian Magierowski | magiero@cse.yorku.ca

TSMC 0.13µm CMOS

A 16-channel Self-contained Multi-modal Implantable Brain Neural Interface

Applications include: Health/Biomedical

This project's main objective is design, simulation, and experimental characterization of a 16-channel wireless and battery-less implantable microsystem for multi-modal neural interfacing. The SoC will be used for simultaneous measurement and real-time analysis of neuro-chemical and neuro-electrical brain activity, as well as for responsive electrical stimulation of the brain. It will be used to study the root cause of brain functions and dysfunctions in a multi-modal fashion. This can be helpful for research studies on neurological disorders such as Alzheimer's disease and seizure detection and control for epilepsy. To analyze and predict/detect the onset of a neurological event, chemical and electrical data will be fed to an on-chip processing unit or sent to a computer using on-chip wireless transmitters. The system will be powered up using an on-chip receiver coil, which removes the need for a battery or an on-board receiver coil. The same on-chip coil will be used for data communication.

York University
Designer: Alireza Dabbaghian | dalireza@yorku.ca
Professor: Hossein Kassiri | hossein@eecs.yorku.ca

TSMC 0.13µm CMOS

A 28-31 GHz Bi-directional Amplifier for 5G Wireless Repeaters

Applications include: ICT

The fifth generation (5G) wireless networks is expected to operate in mm-wave bands, such as 28-31 GHz. The 5G wireless links can be easily disrupted if line of sight (LoS) between the transmitter (TX) and the receiver (RX) is broken. In this design, we seek to demonstrate a Bi-directional Amplifier (BDA), which is intended to operate inside wireless repeaters to extend the 5G coverage to unreached areas, where the TX-RX LoS is broken. The BDA achieves a gain of 18 dB in both directions, while the reflection coefficients S11 and S22 < -10 dB. The 1-dB compression point is -20.3 dBm.

Queen's University
Designer: Arthur Costa |15altc@queensu.ca
Professor: Carlos Saavedra | carlos.saavedra@queensu.ca

TSMC 0.13µm CMOS

An Energy-Efficient CMOS Biophotometry Sensor with Incremental DT-DSM ADC Conversion

Applications include: Health/Biomedical

In this design, we will develop an energy-efficient CMOS biophotometry sensor using an incremental discrete time ADC all integrated inside a CMOS system-on-a-chip (SoC). This SoC will be the core of an implantable and high-precision optical neural interface microsystem. In fact, fluorescence biophotometry measurements require wide dynamic range (DR) and high sensitivity measurement tools. This design provides these key characteristics to collect Ca2+ ionic transfers resulting from brain activity within a freely moving animal photometry scheme with low illumination. In addition, it will provide optogenetic photo-stimulation as well for enabling optogenetically-synchronized fiber photometry. For that purpose, an LED driver will activate an LED to illuminate neurons, expressed by genetically encoded calcium indicators, through a brain-inserted multimodal fiber. The fiber will be coupled to the LED and with the high-dynamic range bio-photometry sensor to collect the evoked neural activity. The developed device will be evaluated in-vitro and in-vivo at the CERVO Brain Research Center to validate and to measure its functionality and performance.

Université Laval
Designer: Mehdi Noormohammadi Khiarak | mehdi.noormohammadi-khiarak.1@ulaval.ca
Professor: Benoit Gosselin | benoit.gosselin@gel.ulaval.ca

TSMC 0.13µm CMOS

CMOS Wireless Power Receiver for Biomedical Implants

Applications include: Health/Biomedical

The design includes rectifier, Low-dropout regulator (LDO) and Bandgap reference blocks for wireless power transfer system. The overall power consumption needs to be controlled within 100 uW to satisfy the limited power budget of typical biomedical applications.

University of British Columbia
Designer: Ziyu Wang | ziyuwang@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 0.13µm CMOS

Efficient Radio Frequency Energy Harvesters

Applications include: ICT, Environment, Natural Resource/Energy

In this project we will design and fabricate radio frequency (RF) energy harvesters capable of converting ambient RF energy to DC with high efficiencies over a large input power range. The proposed RF energy harvesters can be used to power up a range of wireless sensors and actuators for applications like Internet of Things, Harsh Environment Monitoring, among others. Elimination of batteries can help these technologies to scale to qualities that was not previously possible.

University of Alberta
Designer: Mohammadamin Karami | mkarami@ualberta.ca
Professor: Kambiz Moez | kambiz@ece.ualberta.ca

TSMC 0.13µm CMOS

Efficient Radio Frequency Energy Harvester with Adaptive Threshold Cancellation

Applications include: Environment, ICT, Natural Resource/Energy

In this project, we will design and fabricate three different RF rectifier with higher efficiencies that conventional one. The first rectifier is made with a new low leakage transistor architecture. Second and third one circuits are new and novel adaptive threshold cancellation schemes that can increase the efficiency of the rectifiers substantially. The proposed circuit can decrease the diode-connected threshold voltage at the negative cycle and increase it when the transistor is off. The proposed RF energy harvesters can be used to power up a range of wireless sensors and actuators for applications like Internet of Things, Harsh Environment Monitoring, among others. Elimination of batteries can help these technologies to scale to qualities that was not previously possible.

University of Alberta
Designer: Mohammadamin Karami | mkarami@ualberta.ca
Professor: Kambiz Moez | kambiz@ece.ualberta.ca

TSMC 0.13µm CMOS

Energy Harvesting Transceiver with Sensors

Applications include: Health/Biomedical, ICT

The main objective of this design is to implement an energy-harvesting transceiver for smart stents, i.e., stents with embedded sensors. Due to the physical size limitations and the nature of the applications (stents being implanted in arteries) efficient energy harvesting for data communication is of paramount importance. Based on preliminary analysis and calculations, the system should be able to operate from 0.5V supply and consume sub 100-uW. The proposed low-voltage and low-power techniques and topologies can also be applied to other low power applications such as other biomedical implants, wireless sensor networks and Internet-of-Things applications.

University of British Columbia
Designer: Mengye Cai | mengyecai@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 0.13µm CMOS

Implantable Power-Efficient Wirelessly Operated System (SoC) for Multi-channel Neural Recording and Optogenetic Stimulation

Applications include: Health/Biomedical

The main goal of this project is to design an implantable SoC that could potentially provide an alternative treatment option for patients with neurological disorders such as Parkinson's disease, epilepsy, and Alzheimer's disease. To eliminate the need for bulky batteries for the envisioned implantable device, the proposed SoC in this project will be designed to receive power wirelessly. The overall system is divided into three main sub-blocks of power management unit, multi-channel neural recording, and optogenetic stimulation circuitry. The power management unit consists of an efficient rectifier circuit, which converts the received AC power into DC, and a regulator circuit, which provides a stable supply for system's sub-blocks. Furthermore, this unit consists of efficient charging circuitry which is essential in providing high instantaneous power required within the system for short durations. The multi-channel recording is to be capable of amplification and digitization of the recorded signals for reliable real time neurological monitoring under minimal power consumption. The optogenetic stimulation is beneficial in improving temporal and spatial resolutions by utilizing light to conduct optical stimulation of genetically modified brain cells. The functionality of the fabricated prototype will be validated through in-vitro and in-vivo experiments in collaboration with neurologists and neurosurgeons at York University.

York University
Designer: Mansour Taghadosi | mtaghadosi@eecs.yorku.ca
Professor: Hossein Kassiri | hossein@eecs.yorku.ca

TSMC 0.13µm CMOS

Memory Chip - Heterogeneous Integration of High-Density analog Crossbar for Advanced Data Processing
Applications include: ICT

In this project, an efficient and versatile system for the future development of machine learning hardware is to be designed, and more precisely, a scalable, flexible and innovative strategy for the implementation of the synaptic weight and the associated Multiply and Accumulate operation, one of the most demanding resource for efficient ML hardware will be developed. We will capitalize on an ideal balance between CMOS performance and specific features available with emerging memory devices (i.e. synapses). This project comprises of two chips: Memory chip and CMOS chip. This application is filled for the Memory chip. We will implement a massively parallel and dense memory array via multiple passive crossbar interconnection in a system-on-chip strategy. Active amplification between passive crossbars will enable ultra-high memory density while preserving optimal control of the memory devices. The memory chip contains 800x800 memory cells by using a special design to reduce the effect of sneak path currents considerably.

University of Toronto
Designer: Amirali Amirsoleimani | amirali.amirsoleimani@utoronto.ca
Professor: Roman Genov | roman@eecg.utoronto.ca

TSMC 0.13µm CMOS

Motion-resilient Wearable EEG Recording Chip with Full Impedance Considerations
Applications include: Health/Biomedical

This project's main objective is design, simulation, and experimental characterization of an 8-channel dry electrode wearable wireless EEG system for non-invasive monitoring and diagnostic applications. The SoC will be used for simultaneous recording and real-time analysis of neuro-electrical brain activity. The device will be primarily used for early detection of neurological abnormalities to prevent further damage to the brain. Considering that the artifacts induced by motion are the most significant source of noise/distortion coupled onto the recorded signals for non-invasive EEG recording, a motion artifact detection and removal module will be integrated in each channel. The novel architecture that we will use for this module allows for conducting the artifact removal in the analog/mixed-signal domain. Compared to the state of the art that implement this module in the digital domain, the proposed design has the advantage of full artifact removal while preventing amplifier saturation even with very large artifacts. The SoC, together with a low-power FPGA and a wireless transmitter will be integrated on a miniaturized printed circuit board to form the envisioned wearable medical device.

York University
Designer: Alireza Dabbaghian | dalireza@yorku.ca
Professor: Hossein Kassiri | hossein@eecs.yorku.ca

TSMC 0.13µm CMOS

Reconfigurable Impulse Radio Ultra Wideband (IR-UWB) Current Mode Switched Receiver
Applications include: ICT (Radio Frequency Integrated Circuits)

There is a strong motivation to create a low-cost, high-speed, energy-efficient wireless communication link that can support all services and standards. The proposed design is a multi-band with reconfigurable capability receiver. It mainly consists of a Low-power differential UWB low noise amplifier (LNA) with high power gain and flat in band noise figure (NF), a squarer and baseband amplifier to achieve low power consumption, and high-speed wide bandwidth communication capability. Our design aim is to create a fully integrated receiver RF front-end which can cover wide frequency range and support several standards such as IEEE 802.15.4a

École de technologie supérieure
Designer: Amin Pourvali Kakhki | amin.pourvali-kakhki.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

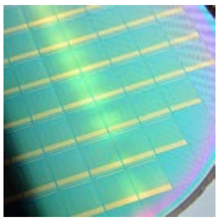
TSMC 0.13µm CMOS

Ultra Low Power Circuits for Wearable Flexible Sensors in Healthcare Applications

Applications include: Health/Biomedical

This project is to verify the basic circuit blocks for wearable flexible sensors in monitoring vital signs. Ultra high impedance analog frontend suitable for dry electrodes and low power wireless receiver for data communications will be designed for flexible sensors.

York University
Designer: Zhongxia Shang | zxshang@cse.yorku.ca
Professor: Yong Lian | peterlian@cse.yorku.ca



Technology: 180-nanometer CMOS

TSMC 0.18µm CMOS

High-speed High-sensitivity CMOS Imaging Sensor

Applications include: Health/Biomedical, ICT

The field of optical radiation sensors/detectors and imaging systems is rapidly growing. We plan to use standard CMOS technologies to design one of the most sensitive silicon detectors – the digital Silicon Photo-multiplier (dSiPM) that incorporate high-speed digital circuitry for accurate timing information and single photon avalanche diodes (SPADs) for extremely low levels of light detection. Our primary objectives are: (1) to optimize the design and experimentally study advanced digital SiPM for biomedical imaging applications such as fluorescence lifetime imaging microscopy (FLIM) and Positron Emission Tomography (PET) from a low-cost, mainstream deep-sub-micron technology; (2) to develop guidelines as to how to lay out SPADs with optimal dimensions in regard to improving speed and reducing noise; (3) to investigate the methods and techniques for the integration between the SPAD and the front-end and the following digitally processing circuits. The dSiPM consists of an array of SPADs and required digital integrated circuits such as quenching and reset circuits, and time-to-digital convertor (TDC). In order to obtain the excellent performance of the dSiPM, efforts are needed to enhance the performance SPAD cell itself. In this design, we will investigate 3 aspects of SPADs: afterpulsing probability (AP), photon detection efficiency (PDE) and the timing resolution. Simulations will be used to obtain an optimized layout and design for best optical/electrical performance. The fabricated chip will be then tested to verify the performances. SPADs will be designed in deep-submicron (DSM) technologies for the potentials to integrate the digital processing circuits with the sensor to build a system on same chip. Such integration will help to improve the optical and electrical performance and lower the cost and size of sensors. These favorable features will make the improved the dSiPM an attractive, high-performance integrated sensor for medical imaging system.

McMaster University
Designer: Wei Jiang | jiangw35@mcmaster.ca
Professor: Jamal Deen | jamal@mcmaster.ca

TSMC 0.18µm CMOS

Hybrid Linear Regulator

Areas of application include: ICT

When designing microelectronics circuits, powering the circuit is often an afterthought. As power consumption, specifications shrink further, so do voltage supplies. Despite the dazzling specifications some designers achieved; applicability can be constrained, and this often leads to shelved designs or impracticable efficiencies. This is especially true when dealing with sub 1-volt supplies and very low currents. In this paradigm, linear regulators waste everything between the upper circuit rail voltage and max battery voltage as a product of that difference and current. Switching regulator on the other hand suffer from switching losses and coil core losses. As designers strive to reduce overall voltage and power these problems become increasingly significant because the lowered supply rail rarely results in significant system efficiency. This problem occurs in designs that are ultimately destined for implantable devices but in the end lack this power practicality. The objective of this project is to create a novel hybrid regulator that uses a current reuse scheme a diverting current sluice and an analog controller circuit to regulate and balance current through the circuit providing the appropriate voltages to different system domains. Analog control system implement with 2 variable feedback loop. The device regulates not only output voltage but also load current and recycles power within the first regulators voltage drop. A version of the circuit based on discrete components has been tested and works but miniaturization and lower voltage regulation cannot be efficiently achieved with discrete components.

Université Laval
Designer: Eric Bharucha | ericbha@videotron.ca
Professor: Benoit Gosselin | benoit.gosselin@gel.ulaval.ca

TSMC 0.18µm CMOS

Integrated Microwave Sensor

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

Planar microwave structures have demonstrated significant advantages and strong potentials in material sensing and detection applications. Their simple, miniaturized, and CMOS compatible structure have made them attractive for portable and low-power sensing systems structures. In this work, a sensor structure based on planar microwave structures along with a readout circuitry will be monolithically implemented on a single CMOS chip. The sensor operates at 1GHz and interacts with its near environment through the electric field. A novel ring oscillator structure with a key focus of low-power operation is designed, simulated and implemented in layout. Post-layout simulations are performed on the extracted structure by Calibre and demonstrates a good match with initial schematics simulations. To eliminate process variation parameters and temperature change on the chip and its effect on the oscillation frequency, a reference oscillator is designed and implemented very close to the sensor oscillator to be operated as a reference oscillator. To avoid any negative impact from pads and final packaging pins, such as capacitive or inductive loading and filtering effect on the signal at microwave frequency, a one step down conversion is performed on the chip and the output signal will be presented on high frequency domain.

University of British Columbia
Professor: Mohammad Zarifi | mohammad.zarifi@ubc.ca

TSMC 0.18µm CMOS

Long-term Implantable Ambulatory EEG Monitoring SOC

Applications include: Health/Biomedical

The Objective of this design is to enable long-term ambulatory EEG monitoring using an implantable SOC for neurological diagnosis and real time monitoring of EEG signals over an ultra-Low power wireless link. Conventional EEG monitoring systems have significant limitations for long-term monitoring application including unreliable electrode to skin connection (for extended period), being prone to motion artifacts and creating obstacles for patients in their daily activities/routines due to the size and wire connections. Long-term EEG monitoring enables diagnoses of infrequently occurring neurological symptoms as well as providing real-time and potentially lifesaving alerts to patients with disorders such as epilepsy. The proposed low-power, battery operated EEG monitoring SOC will be fully implantable and relies on wireless technologies for both data communication and power transfer, as the result any effect of motion artifacts or electrode connection unreliability is virtually eliminated, it also won’t cause any limitations to patient’s daily activities due to its compact size and elimination of all external parts. Fabricated prototypes will be validated in vivo in collaboration with neurosurgeons and neurologists at Toronto Western Hospital. This project involves the design, simulation and experimental characterization of a long-term implantable EEG monitoring SOC solution and subcomponents such as ultra-low power wireless comminutions and inductive power reception.

York University
Designer: Al Freeman | afreema@yorku.ca
Professor: Hossein Kassiri | hossein@eecs.yorku.ca

TSMC 0.18µm CMOS

Low Power, Digital Readout for 3D Digital Silicon Photomultiplier

Applications include: 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. These photodetectors are found in many applications such as medical imaging (positron emission tomography), 3D cameras and low light/low background physic experiments. SPADs are polarized over their breakdown voltage to maximize their photon sensitivity (single photon sensitivity). To preserve the SPAD integrity, it is essential to quench the current with either a passive (resistor) or an active circuitry and rearm it subsequently. This is done with a front-end circuit called a quenching circuit. With an analog Silicon Photomultiplier (aSiPM), the quenching circuit is simply done with a resistor, restricting functionalities. On the other hand, a digital SiPM (dSiPM) offers a multitude of functionalities. The proposed design, built in a TSMC 180 nm BCD CMOS technology, implements an array of quenching circuits with programmable holdoff and recharge time. Moreover, each SPAD can be individually disabled if it is too noisy. Finally, a digital sum of all SPAD over the array is done at a maximum frame rate of 200 MHz. A big challenge that is being addressed in this design is its low static power consumption (< 250 µW for the ASIC), compared to our other readout ASIC optimized for fast timing measurements in TSMC 65 nm.

Université de Sherbrooke
Designer: Nicolas Roy | nicolas.roy6@usherbrooke.ca
Professor: Jean-François Pratte | jean-francois.pratte@usherbrooke.ca

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TSMC 0.18µm CMOS

Low-power High-efficiency Power Management Unit Design

Applications include: Health/Biomedical

This design is aiming to verify the newly proposed thermo-electrical energy harvesting system. This system has features as low-power and high-efficiency.

York University
Designer: Zhongxia Shang | zxshang@cse.yorku.ca
Professor: Yong Lian | peterlian@cse.yorku.ca

TSMC 0.18µm CMOS

Multimodal CMOS Sensor Array

Applications include: Health/Biomedical

This chip consists of an array of 10x10 capacitive sensors for drug screening. A microfluidic structure with 10X10 chambers is bonded with this chip. The capacitance in between two microelectrodes realized on the topmost metal layer in CMOS is used as a biomarker to assess the viability of cell. The non-resistant cells exposed to drug demonstrate a very low capacitance and the drug resistant cells cultured om the electrodes will demonstrate a very high capacitance. This CMOS capacitance sensing system consists of a capacitance to voltage block. The output of CVC block is converted to digital using a low frequency ADC. The digital output is transferred to computer for data analysis and signal processing.

York University
Designer: Hamed Osouli Tabrizi | htabrizi@cse.yorku.ca
Professor: Ebrahim Ghafar-Zadeh egz@cse.yorku.ca

TSMC 0.18µm CMOS

Photostimulator for Optogenetics with Live Animals

Applications include: Health/Biomedical

This chip realizes a wireless photostimulator providing high output power from small battery to stimulate light sensitized neurons in the brain of small transgenic laboratory animals (such as rat or mice). The proposed photostimulator is based on a DC/DC converter that will provide high voltage (up to 4 V) to the stimulating LEDs, from a small sized battery source (eg. coin battery). The LED currents will be regulated by an on-chip precise LED driver. The DC/DC converter will be used to boost the battery voltage level up to 4 V, as to accommodate the LED used for optogenetics (Vforward up to 3.3V). The outputted current of the proposed LED driver circuit will be adjustable, as to provide different optical power levels to the neurons. The part of the converter that has already made by CMC will be placed beside another design to have a complete circuit. In the new version, we will increase the frequency to decrease the sizes of the other components.

Université Laval
Designer: Anita Ebrahemyan Masihi | anita.ebrahemyan-masihi.1@ulaval.ca
Professor: Benoit Gosselin benoit.gosselin@gel.ulaval.ca

TSMC 0.18µm CMOS

Ultra Low Voltage Neural Front End

Applications include: Health/Biomedical

Current amplifier front ends have been greatly optimized in the last 2 decades but have reached a physical limit that prevents practical improvements required for use in neural prosthetics and rehabilitation. One major limiting factor in achieving successful and reliable systems is power consumption. As described in [1], power consumption limits the number of neural detection channels, but it also has another deleterious effect such as implant temperature. It is accepted that a higher number of channels will provide richer information for control and diagnostics. For safety reasons the thermal limits in implantable devices is limited to an increase of 2C above body temperature [2]. Although there have been some devices achieving lower consumption they have done so at the cost of degrading performance beyond a usable limit. The current design approach does not rely solely on voltage gain techniques to extract the signal. Despite the low supply voltage preliminary work show that biasing and gain are achievable to a sufficient level to extract the signal. The design consists of a differential pair front end, which then feeds the signal into current mode stage where it is amplified and compared to a baseline current in a resettable switched comparator. The second stage circuit is reminiscent of a winner take-all-circuit.
The design requirements are:

- Gain equivalence when compared to conventional voltage mode devices should be 40dB+/-5dB for the overall system 2 stages. This is the minimum observed for signal extraction.
- CMRR shall be of minimum 40 dB
- Phase Margin shall be at least 40 degrees
- Input referred noise shall be less than 5uVrms
- DC offset shall be less than 50% of the final rail to rail supply
- Frequency response shall be of at least 4kHz to resolve spikes of 0.5ms
- Power Consumption shall be under 1uW
- Neural Spike detection: The output comparator shall detect an action potential with a success rate of 85% when compared to a reference

Université Laval
Designer: Eric Bharucha | ericbha@videotron.ca
Professor: Benoit Gosselin | benoit.gosselin@gel.ulaval.ca

Technology: 350-nanometer CMOS

AMS 0.35µm CMOS (Base/OPTO)

A QVGA Computational Image Sensor for Coded-Exposure based 3D Imaging

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

Focal-stack 3-dimensional (3D) imaging refers to a computational imaging technique where pixel-wise coded exposure is applied to program the light illumination on the image sensor (the sensor domain). To acquire a focal-stack coded image, a sequence of binary mask patterns is applied to control sensor's exposure along with the variation of camera's focal length. Previous research in the focal-stack 3D imaging has shown that coded exposure is a very effective method in actively probing light transport and can therefore provide many potentially promising 3D imaging applications such as depth sensing, defocus de-blurring, and all-in-focus imaging with an improved accuracy an d/or power efficiency. In this work, we design pixels with lateral electric-field modulation (LEFM) structure and embedded static random-access memory (SRAM) cells which are responsible for applying both in-pixel optical modulation and the storage of exposure codes. The exposure binary code (mask) can therefore be loaded for exposure, resulting in a pipelined coding operation which does not interfere with the pixel exposure time. The mask loading is done serially via a vertical metal line (one line per-column), making both the image sensor and the pixel array scalable towards high pixel resolutions.

University of British Columbia
Designer: Yi Luo | luoyikey@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

AMS 0.35µm CMOS (Base/OPTO)

CMOS Computational Image Sensor with Pixel-Wise Compressive Sensing for Focal-Plane Machine Vision

Applications include: Automotive, Entertainment, Health/Biomedical

Focal plane compressive sensing refers to an active exposure technique where coding is applied to the light illumination on the image sensor (the sensor domain). To acquire a coded image, a sequence of binary mask patterns is applied in lockstep to control sensor's exposure. Previous research in computational imaging has shown that coded exposure is a very effective method in actively probing light transport and can therefore provide many potentially promising compressive sensing based applications such as eliminating high-speed motion blur, improving the accuracy and/or power efficiency of structured light, and focal-stack 3D imaging. In this work, we design pixels with 2-tap lateral electric-field modulation (LEFM) structures and embedded SRAM memory cells which are responsible for applying both in-pixel optical modulation and the storage of exposure codes. The exposure binary code (mask) can therefore be loaded for pixel-wise exposure, resulting in a pipelined coding operation which does not interfere with the pixel exposure time. The mask loading is done serially via a vertical metal line (one line per-column), making both the image sensor and the pixel array scalable towards high pixel resolutions.

University of British Columbia
Designer: Yi Luo | luoyikey@ece.ubc.ca
Professor: Shahriar Mirabbasi | shahriar@ece.ubc.ca

TSMC 0.35µm CMOS

CMOS Olfactory Sensors Platform

Applications include: Natural Resource/Energy (platform technology applicable to many different market sectors. At present, the system is being developed for application in the classification of different fuels produced in the petroleum industry)

This design is a follow-up to our integrated olfactory sensor array project by using a standard CMOS silicon fabrication process. This project has been used for training of 3 students in the past and a PhD student is continuing. A patent disclosure has been filed for this technology. Under the project, an olfaction system is being developed that is based on integration of gas sensitive conducting polymers and Floating Gate Metal Oxide Semiconductor (FGMOS) sensors. A sensing polymer, polypyrrole for example, is electrochemically deposited onto sensor pads which are electrically connected to floating gate of the sensor. Using an array of floating gate sensors, coupled to these chemically diverse polymers, will facilitate a signature-like response for every individual sensor in the array. In this work, an array (8 x 8) of sensors has been designed where every sensor can be accessed and analysed individually using a specially designed addressing circuit. The response from the sensors which is often in range of picoamperes to milliamperes is amplified through a trans-impedance amplifier and converted to 8-bit digital data for ease of analyte identification and quantification. Past design runs have confirmed the feasibility of our objective of developing an olfaction system on chip. In the present run we plan to make some small changes to optimise the previous design of the system in order to improve the performance.

University of Manitoba
Designer: Vaibhav Dubey | dubeyv@myumanitoba.ca (now Vaibhav@cmc.ca)
Professor: Douglas Buchanan | douglas.buchanan@umanitoba.ca

AMS 0.35µm CMOS

High Voltage ASIC Driver Array

Applications include: Other (astrophysics)

The proposed design implements an increasingly popular technique in analog circuit design, which combines the desirable properties of a continuous time (analog) circuit with those of a switching mode (digital) design. Our application involves the development of a dedicated ASIC voltage driver chip that is motivated by the increasing demand for an adaptive optics (AO) system scalable to the largest class of optical/NIR telescopes. In this design, the digital input signal (e.g. from a wave front sensor (WFS)) will undergo digital signal processing (DSP) in which a pulse width modulation (PWM) or delta sigma modulation technique will be used to encode the desired signal into pulses. Once this occurs, the signal will be suitable to input into a high voltage (HV) switching mode driver, a commonly used driving option in MEMS applications. A prototype switching mode driver that minimizes the use of problematic HV transistors and can provide a +/15V bipolar signal to drive an array of electrostatic actuators has been designed. The design implements a series of inverter stages with increasing size standard buffer cells to condition the drive signals before applying them to the HV transistors at the output. This increases the load driving capability of the circuit and allows us to use a minimal number of HV transistors. The HV transistors required at the output stage are subject to a highly stable drive pulse between 15 V and 11.7 V that is achieved using a HV transistor and a voltage divider consisting of two large resistors at the input. The overall result is that for a pulsed input signal between 0 V and 3.3 V, a bipolar +/15V output signal is produced.

Dalhousie University
Designer: Colin Ross | colin.ross.dal@gmail.com
Professor: Kamal Elsankary | km229278@dal.ca

AMS 0.35µm CMOS

Power IC for LED Signage

Applications include: Entertainment, Environment

A new highly efficient multiple-output DC/DC converter will be fabricated in order to drive multiple LEDs.

University of Calgary
Designer: Dawood Shekari Beyragh | dawood.shekaribeyrag@ucalgary.ca
Professor: Majid Pahlevani | majid.pahlevani@ucalgary.ca

TSMC 0.35µm CMOS

Scalable Lateral Resolution Improvements for SPM

Applications include: ICT and others (microscopy and microanalysis)

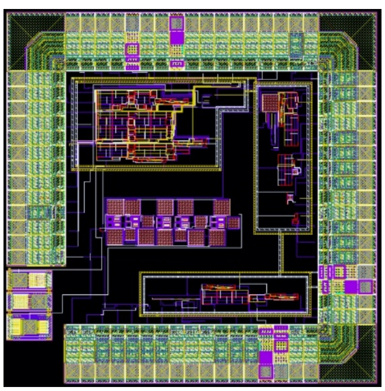
Designs on this chip include devices with capabilities for improved lateral resolution of single-chip CMOS-MEMS scanning probes microscopes (SPMs), manufactured using a novel, high-throughput process. The lateral resolution of SPMs is dictated by the sharpness (radius of curvature) as well as the shape (e.g., cone angle) of the probe tip. A new, scalable manufacturing process will be developed to control both the sharpness and shape of CMOS-MEMS SPMs probes for the first time. The designs on this chip represent improvements that allow for this new scalable process, as well as improvements to the robustness of the devices to post-processing and assembly. Other designs on this chip are new research devices that offer improvements in the size of both lateral and vertical scanning area of our CMOS-MEMS SPMs.

University of Waterloo
Designer: David Morris | david.morris@uwaterloo.ca
Professor: Raafat Mansour | rrmansour@uwaterloo.ca

AMS 0.35µm CMOS

Time-gated SPAD Array Integrated with CMOS Driven VCSEL for On-chip Time Resolved Fluorescence Measurements

Applications include: Health/Biomedical



In this project we aim to develop an array (32 x 8) of time-gated single-photon avalanche diode (SPAD) sensor integrated with pulsed light source. A time-gated sensor array is used to detect photons in some specific time windows and the gating pulse frequency can extend up to 120 MHz with a gate-ON time-period up to 35 nanoseconds. The pulsed light emission unit uses a 50 GHz GaAs Vertical Cavity Surface Emitting Laser (VCSEL) diode. Both the light emission and gated-detection modules are driven by a synchronization block. The proposed module is portable, non-invasive and fully user-configurable via a Universal asynchronous receiver-transmitter (UART) interface. It can be seen as a scaled down version of Time Resolved Diffuse Optical Spectroscopy (TR-DOS) system that can be integrated in any optical setup and effectively utilized in many applications such as optical mammography and functional brain imaging.

Polytechnique Montréal
Designer: Sreenil Saha | sreenil.saha@polymtl.ca
Professor: Frédéric Lesage | frederic.lesage@polymtl.ca

AMS 0.35µm CMOS

Ultrasonic Imaging Front End for Tilted Plane Wave Emission

Applications include: Health/Biomedical

The proposed microchip consists of an analog front end for a CMUT based ultrasound probe for plane wave imaging. Plane wave imaging requires a precise control of the delay between each pulsing element. Traditionally, these delays are sequentially programmed for each pulser every acquisition. We aim to develop an integrated variable delay line that could replace this time-consuming process. The inter-element delay should allow for a maximum of +/-20 degrees tilt of the plane wave. As a proof of concept, a vector of eight high voltage pulsers controlled by this delay line will provide enough current (30mA) to drive a custom made CMUTs array at its resonant frequency, 25MHz. This high frequency allows high spatial resolution, suitable for vascular imaging. Recent developments have proven that bipolar pulses increase the output power of this type of transducers. Therefore, three level pulsers will be integrated on-chip whereas most design in literature only use a two-level pulsing scheme. The design will include an improved version of a transimpedance amplifier (TIA) array. Eight TIA will be integrated on chip, with better matching with the transducers (lower central frequency). A RX/TX HV switch will protect these elements from the high voltage pulses. The output impedance of the receiving path will be tuned to 50 ohms to match the signal wire impedance.

Polytechnique Montréal
Designer: Antoine Letourneau | antoine.letourneau@polymtl.ca
Professor: Mohamad Sawan | mohamad.sawan@polymtl.ca

PHOTONICS & OPTOELECTRONICS

Technology: III-V Epitaxy

Azastra

III-V Hetero-structures on Germanium for High Efficiency Solar Cells Fabrication

Applications include: Natural Resources / Energy

Growth of a III-V hetero-structure on Germanium to form high efficiency solar cells with various design and contact architectures.

University of Sherbrook
Designer: Maxime Darnon | maxime.darnon@usherbrooke.ca
Professor: Simon Fafard | simon.fafard@usherbrooke.ca

Azastra

High Efficiency Duplicated GaAs Solar Cell

Applications include: Natural Resources / Energy

A new high efficiency GaAs solar cell heterostructure for ultra high concentration photovoltaic application

University of Sherbrook
Designer: Mourad Jellite | mourad.jellite@usherbrooke.ca
Professor: Richard Arès | richard.ares@usherbrooke.ca

FBH Germany

Nonlinear Plasmonic AlGaAs Waveguides

Applications include: ICT

The purpose of our research is to investigate the use of plasmonic slot waveguides in AlGaAs to perform four wave mixing.

University of Toronto
Designer: Kyle Johnson | E: ka.johnson@mail.utoronto.ca
Professor: Steward Aitchison | E: stewart.aitchison@utoronto.ca

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NRC-CPFC

Integration of Semiconductor Optical Amplifier with Silicon Photonic Modulators

Applications include: ICT

We plan to explore the integration of III-V Semiconductor Optical Amplifier (SOA) chips with Silicon Photonic (SiP) systems. This proposal seeks to grow SOA structures that will be post-growth processed in the Centre for Emerging Device Technologies at McMaster University. The SOAs will then be coupled with existing and proposed SiP chips to demonstrate system amplification >10dB. Integration will involve co-packaging of SOA and SiP chips using a single sub-carrier. The challenges associated with this approach involve precise optical alignment using traditional and advanced packaging technology, and the integration of components with varying electrical, mechanical and thermal properties.

McMaster University
Designer: Mengyuan Ye | yem11@mcmaster.ca
Professor: Andrew Knights | aknight@mcmaster.ca

Technology: Silicon Photonics – Active Silicon on Insulator

AMF SOI

Biochemical Sensor

Applications include: Environment

Medical diagnostics are critical in reducing treatment costs and improving outcomes by facilitating preventative care, early intervention, and targeted therapy. They affect 60-70% of all treatment decisions but only account for about 13% of all healthcare related costs \cite{Medical diagnose}. However, modern diagnostic tools, like enzyme- linked immunosorbent assay (ELISA), still require trained operators and secondary amplification steps with complex logistics and information management for data analysis \cite{problem3}, which restricts its adoption for fast in-field testing, especially in developing countries. Silicon photonics is foreseen to be tomorrow's main technology for the high-speed telecommunication and datacenter markets. Massive investments are being made throughout the world to boost fundamental and applied research and enable mass production at low cost. Silicon photonic biosensors have attracted increasing attention in the past 10 years due to their potential to be used for environmental monitoring, biothreat-associated agent detection, healthcare and basic biomedical research [4]. Nowadays, by leveraging the low-cost mass-production of CMOS foundries, these biosensors have recently become competitive in terms of fabrication cost. But most importantly, they will be able to address the urgent need for Point-of-Care and personalized medicine, including in remote and low-resource settings worldwide. Recently, we have successfully developed a system-level architecture based on photonic-electronic (i.e. active) chips allowing a single optical input to be distributed to multiple microring resonators (MRRs), each one individually monitored by an on-chip germanium photo-detector (PD). Silicon dies of only 1 mm2 but integrating 16 independent MRRs and PDs were fabricated through a multi-project wafer service in a CMOS foundry.

University of British Columbia
Designer: Enxiao Luan | eluan@ece.ubc.ca
Professor: Karen Cheung | kcheung@ece.ubc.ca

AMF SOI

Flex-Processing of Silicon Photonic Circuits Using Integrated Micro-platforms

Applications include: ICT

This design will permit the prototyping of devices and systems that will rely on the newly developed Flex-Process, which is currently under patent application via McMaster University. Flex-P permits flexible strategies for local processing of silicon photonic circuits; including the integration of detectors and amplifiers, and the trimming of resonant structures post-process. This design will include high-speed modulators trimmed to work on the ITU grid; with integrated detectors, and integrated amplfiers formed post-process. Success will allow a commercially important, high-profile technology to be disseminated.

McMaster University
Designer: David Hagan | hagand3@mcmaster.ca
Professor: Andrew Knights | aknight@mcmaster.ca

AMF SOI

Integrated Optical Cavity Sensors for Mechanics

Applications include: Health/Biomedical (experimental physics)

Photonic waveguides and detectors with nanomechanical structures in proximity.

University of Alberta
Designer: Miro Belov | mbelov@ualberta.net
Professor: Mark Freeman | mark.freeman@ualberta.ca

AMF SOI

Mach-Zehnder Interferometer Based on Bent Contra-Directional Coupled Ring Resonators

Applications include: ICT

We propose a microring-assisted Mach Zehnder Interferometer (RAMZI) that integrates microring resonators (MRRs) with bent contra-directional couplers (CDCs) in an MZI to create a modulator where phase modulation is achieved by electrically shifting the phase response of the MRR. The design suppresses the amplitude responses of the MRR and prevents the amplitude modulation that typically accompanies detuning the MRRs. We also propose a multichannel single-side band (SSB) filter which can be used for multichannel SSB signal generation in WDM systems.

University of British Columbia
Designer: Ajay Mistry | ajay.mistry@alumni.ubc.ca
Professor: Lukas Chrostowski | lukasc@ece.ubc.ca

AMF SOI

Novel Integrated Hybrid Optical Waveguides and Devices for All-optical Networking

Applications include: ICT (optical telecommunication)

This design will prepare a foundation for the development of a novel category of highly nonlinear hybrid silicon waveguide devices. These hybrid waveguides will lead to devices enabling wavelength conversion with low optical power and possibly simplify and accelerate the treatment of optical data. These photonic devices are of great interest for ultrafast all-optical networking, which are based on keeping the data signal entirely in the optical domain from source to destination. Our goal is to design a hybrid waveguide by incorporating highly nonlinear materials such as MALH (methylammonium lad halide) perovskite or crystal violet with silicon slot waveguides to enhance the nonlinear response at telecommunication wavelengths, which will lower the power required to observe nonlinear phenomena. Moreover, we hope to overcome the limitations of silicon nanowaveguides by avoiding the nonlinear loss caused by two-photon absorption in silicon at the wavelengths of interest. The slot waveguide configuration generates high optical field intensities in the slot, which enhances nonlinear interactions with the material deposited in the slot. The design will consist of an array of silicon slot waveguides of different length and slot width. This design will also contain slot waveguide ring resonators, Y-splitter and MZI to demonstrate basic nonlinear processing with the novel waveguides including wavelength conversion, frequency comb generation and sensing.

Université du Québec à Montréal
Designer: Devika Padmakumar Nair | devika.padmakumar-nair.1@ens.etsmtl.ca
Professor: Yves Blaquière | yves.blaquiere@etsmtl.ca

AMF SOI

Programmable Microwave Photonic Signal Processor on a Silicon Photonic Chip

Applications include: Defence (Safety, Security), ICT

The objective of the project is to design, fabricate and evaluate a programmable photonic signal processor on a silicon photonic chip for microwave signal processing. The programmable processor has a two-dimensional mesh network structure with multiple input and multiple output ports. In each mesh cell two identical thermally-tunable high-Q microdisk resonators (MDRs) are used for routing and processing the optical signal, and a low-loss waveguide crossing is employed to allow simultaneous processing optical signals. The MDR is designed to incorporate an additional slab waveguide to wrap the disk and bus waveguide, which is of help in increasing the light confinement capacity, and a micro-heater is placed on top of the disk for thermal tuning. By programming the bias voltages applied to the MDRs, the processor could be reconfigured to perform diverse signal processing functions including spectral filtering, phase shifting, temporal integration, temporal differentiation, Hilbert transformation, pulse shaping, frequency discrimination, tunable true time delay, and phased array beamforming. The device has the key advantages including strong reconfigurability and parallel computing with a low power consumption.

University of Ottawa
Designer: Weifeng Zhang | Wzhan088@uottawa.ca
Professor: Jianping Yao | jpyao@site.uottawa.ca

AMF SOI

Rare-earth Doped Chalcogenide Laser on the Silicon-on-Insulator Platform

Applications include: Natural Resources / Energy

This project aims to develop a laser on the silicon-on-insulator (SOI) platform by integrating rare-earth doped chalcogenide (ChG) glass as a gain medium embedded in a novel hybrid waveguide geometry. The glass will be deposited through a single-step post-process, while the etched silicon layer will provide guiding and optical feedback. We will examine the performance of a DBR laser cavity emitting at 2.0 microns.

Université Laval
Designer: Philippe Jean | philippe.jean.4@ulaval.ca
Professor: Wei Shi | wei.shi@gel.ulaval.ca

AMF SOI

Rare Earth Amplifiers and Tunable Lasers on a Silicon Photonic Platform

Applications include: ICT

Light emission and amplification are two primary challenges in silicon photonics. With this design we aim to develop a new economic and scalable approach to optical amplifiers and lasers on silicon using rare-earth-doped thin film technology. These ultra-compact and efficient amplifiers and lasers will have a high impact in emerging high-speed optical communications systems.

McMaster University
Designer: Henry Frankis | frankihc@mcmaster.ca
Professor: Jonathan Bradley | bradljd@mcmaster.ca

AMF SOI

Silicon Photonic Networks for Reconfigurable Analog Processing

Applications include: Defence (Safety, Security), ICT

We are designing a number of test systems to implement reconfigurable analog operations using silicon photonic devices. Applications include high efficiency computing, security, and radio frequency communications. We will also continue our development of monolithically integrating electronic components into the IME platform, including operational amplifiers and bipolar transistors.
Primary objectives include:

- testing and development of neural-network inspired photonic processing systems
- circuits for optical steganography and cryptographic key generation
- small-scale optoelectronic logic systems
- PN-doped bipolar transistors for operational and transimpedance amplification

Queen's University
Professor: Bhavin Shastri | shastri@ieee.org

AMF SOI

Wavelength-scale Hybrid Plasmonic Biredirectional WDM Transceivers

Applications include: ICT

The design integrates plasmonic modulators and photodetectors to high index contrast dielectric silicon waveguides on an SOI platform. The aim is to take advantage of high quality SOI processing for low loss waveguides to make very compact microring resonators for WDM and plasmonics for compact device footprints. We will be making multi-channel transceivers and test high-speed signal modulation and reception from devices across wafers.

University of Toronto
Designer: Yiwen Su | yw.su@mail.utoronto.ca
Professor: Amr Helmy | a.helmy@utoronto.ca

Technology: Silicon Photonics – Active Silicon on Insulator Training

Examples of projects using NSERC CREATE Si-EPIC (Silicon Electronic-Photonic Integrated Circuits Program)

IME SOI

- An Analysis of PN Junction Phase Shifters
  McGill University | Designer: Michael Hui | Professor: David Plant
- Coherent Receiver with Flexible Band Splitting
  Université Laval | Designer: Dominique Charron | Professor: Wei Shi
- Demonstration and Design Methodology of Vernier-assisted Mach-Zehnder Modulators
  University of British Columbia | Designer: Mustafa Hammood | Professor: Lukas Chrostowski
- Dense Frequency Comb Generation in Silicon Ring Resonators Using Spectral Self-imaging
  Institut national de la recherche scientifique | Designer: Mohamed Seghilani | Professor: Jose Azaña
- Design for Silicon Micro-ring Modulators
  University of British Columbia | Designer: Ya Han | Professor: Lukas Chrostowski
- Design Principles of Active Silicon Photonics Realized Through Microring Modulators
  McGill University | Designer: James Skoric | Professor: David Plant
- Design, Optimisation and Characterisation of Ring Modulators
  McGill University | Designer: Xueyang Li | Professor: David Plant
- Electrically Pumped G-center in Silicon as a Single Photon Source
  University of British Columbia | Designer: Jingda Wu | Professor: Lukas Chrostowski
- Feedback Rings for Microwave Photonics
  University of Ottawa | Designer: Jian Tang | Professor: Jianping Yao
- Grating Coupler Design for Direct Coupling of Two Modes into a Few-Mode-Fiber
  University of Ottawa | Designer: Houman Ghorbani | Professor: Jianping Yao
- Inter-Coupling Modulation in Contra-Directional Coupled Ring Resonators
  University of British Columbia | Designer: Ajay Mistry | Professor: Lukas Chrostowski
- Monolithic RF Measurement System in SOI
  Institut national de la recherche scientifique | Designer: Saket Kaushal | Professor: Jose Azana
- Multi-Functional Optics Chip for a Fiber Optic Gyroscope System on a SOI Platform
  York University | Designer: Akash Chauhan | Professor: Regina Lee
- Optimisation of the Performances of a High-order Microring Filter Tunable Across the C-Band
  Université Laval | Designer: Simon Bélanger-de Villers | Professor: Wei Shi
- Photodetector Integrated Silicon Photonic Sensor
  University of British Columbia | Designer: Enxiao Luan | Professor: Lukas Chrostowski
- Photonic Analog-to-Digital Converter with On-Chip Pulse Generator
  University of British Columbia | Designer: Donald Witt | Professor: Lukas Chrostowski

- Polarization Encoder for QKD Applications
  University of British Columbia | Designer: Abdelrahman Afifi | Professor: Lukas Chrostowski
- Raman Laser and Amplifier
  Université Laval | Designer: Mohammad Ahamdi | Professor: Sophie Larochelle
- Silicon Photonics Sensors
  University of British Columbia | Designer: Hossam Shoman | Professor: Lukas Chrostowski
- Silicon Photonics Fishbone Nanoantenna
  Université Laval | Designer: Zhongjin Lin | Professor: Wei Shi
- Silicon Photonic Modulator Based on Coupled Bragg Grating Resonators Used as Phase Shifters
  Université Laval | Designer: Omid Jafari Sophie LaRochelle
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Dawson Bonneville | Professor: Jonathan Bradley
- Silicon Photonic Optical Amplifiers and Lasers
  McMaster University | Designer: Khadijeh Miarabbas Kiani | Professor: Jonathan Bradley
- Silicon-Based Applications Using Fano Resonance
  McGill University | Designer: Deng Mao | Professor: David Plant
- The Applications of Ring Resonators Using MMI Couplers
  McGill University | Designer: Reza Maram | Professor: Lawrence Chen
- Transmitter and Receiver Based on MDM on a Silicon Chip
  University of Ottawa | Designer: Neda Nouri | Professor: Jianping Yao
- Wavelength Reuse in an RoF Link Based on DD-OFDM SSBI Cancellation
  University of Ottawa | Designer: Soheil Zibod | Professor: Jianping Yao

Technology: Silicon Photonics – Passive Silicon on Insulator

AMF SOI

8-channel Fast Wavelength Selector for Applications in Wavelength Division Multiplexing (WDM) Communication Systems

Applications include: ICT

Our submission is a silicon photonic integrated circuit (Si-PIC) for an 8-channel fast wavelength selector for applications in Wavelength Division Multiplexing (WDM) communication systems. The wavelength selector is designed to dynamically select any channel wavelength from an input light source consisting of a comb of discrete wavelengths in the C-band (1530 – 1570 nm). The technical challenges addressed in the design are to achieve wide tunability across the full C-band, to achieve fast average switching speed (< 10 us) from one wavelength to another, and to demonstrate scalability and large-scale integration of Si-PICs. The Si-PIC consists of two arrays of 8 microring resonator (MR) filters, each capable of tuning to any wavelength in the C-band. At the input port, a 1x2 beam splitter is used to divide an input comb of WDM wavelengths into two streams, which are fed to the two arrays of filters. Each MR filter is a Vernier cascade of 2 MR stages; each stage is thermo-optically tuned using microheaters. The outputs of a pair of MR filters, one from each filter array, are combined through a 2x1 fast pin MZI switch, which is used to switch the signal from either filter to the output. Each pin MZI switch employs a differential driving scheme on the two arms of the MZI to reduce the drive voltage and increase the switching speed. Target switching time of the MZI switches is < 10 ns. At any instant in time, only one filter in each pair will be selected (on) and the other will be off. The wavelength selection time can be reduced by pre-tuning a filter to the desired wavelength during its "off" time and then switched to the output when required. The submitted circuit is based on a previous design but with improved pin MZI switch and MR filter designs, much greater complexity and larger scale of integration. In particular, the circuit is scaled up to 8 channels, each filter consists of a 4th-order Vernier design that can provide tunability over the C-band.

University of Alberta
Designer: Fnu Aurangozeb | aurangoz@ualberta.ca
Professor: Yang Ren | yr@ualberta.ca

AMF SOI

A 0-40 GHz Silicon Photonic Integrated RF Receiver with Low Phase Noise Characteristics

Applications include: Aerospace, Defence (Safety, Security)

The aim of this research is to develop a silicon-photonics-based 0-40 GHz tunable RF receiver with high performance, chip-scale form factor, remoting capability, and enhanced environmental stability for targeting the requirements of next-generation RF spectrum scanning and analysis systems. In fact, future lightweight and high demanding platforms require the highest level of performance and chip-scale integration at the same time. Unfortunately, microwave technology is revealing unable to achieve the target performance with the desired level of compactness due to its intrinsic bandwidth constraints. In a similar way, current microwave-photonic solutions, in order to solve the problem of the system phase noise introduced by the laser sources, rely on RF or optical components that prevent a chip-scale integration. Instead, the high-performance-receiver design proposed in this project stems from a digital phase-noise cancellation technique able to remove the phase noise introduced by laser sources exploited in the scheme and, at the same time, avoids all the RF/optical components that prevent miniaturization, enabling a full chip scale integration through silicon photonic platform.

Institut national de la recherche scientifique
Designer: Daniel Onori | daniel.onori@emt.inrs.ca
Professor: José Azaña | azana@emt.inrs.ca

AMF SOI

Fabrication of Avalanche Photodector on a Silicon-on-Insulator Platform

Applications include: ICT

Detector responsivity, efficiencies, gain-bandwidth product, noises, etc. will be tested. Equipment such as lasers, probe station, high speed oscillscope, etc. are available at the PI, his collaborators' facilities and through equipment loan from CMC. The test will take approximately 1-2 months.

University of Victoria
Designer: Khashayar Ghaffari | ghaffari.khashayar@gmail.com
Professor: Tao Lu | taolu@uvic.ca

AMF SOI

High-Q Micro-Trench Cavity Light Sources for Silicon Photonics

Applications include: Health/Biomedical, ICT

Integrated light sources are a primary challenge in silicon photonic microsystems. With this design we aim to develop a new economic and scalable approach to lasers and nonlinear optical light sources on silicon using low loss undoped and rare-earth-doped thin films. The thin films will be deposited via post-processing into novel micro-trench cavity structures to be fabricated on the AMF run. These ultra-compact and efficient microcavity light sources will have a high impact in high-speed optical communications systems. The high-Q microcavity structure to be investigated is also of interest for integrated sensing circuits.

McMaster University
Designer: Henry Frankis | frankihc@mcmaster.ca
Professor: Jonathan Bradley | bradljd@mcmaster.ca

AMF SOI

Silicon Photonic Integrated Arbitrary Microwave Waveform Generator

Applications include: Defence (Safety, Security)

The objective of the project is to realize a fully silicon photonic integrated arbitrary waveform generator (AWG) on chip. It utilizes high-Q factor microdisk resonators to achieve high spectrum resolution (narrow to 2 GHz) and large time delay multiple-channel tunable delay lines. Thanks to the high resolution of the multiple-channel tunable delay lines, the required spectrum width of the light source is much smaller. The reduced spectrum makes it possible for the implementation of an on-chip optical frequency comb (except the tunable laser source) to realize the photonic-assisted AWG. The optical comb generator is implemented using two cascaded disk modulators and one phase modulator. The generated comb lines are sent to the tunable delay lines to adjust the time delay, the magnitude and phase. All comb lines at the outputs of the delay lines are coupled to a single waveguide and applied to a photodetector (PD) to generate a targeted microwave waveform. The system has the key advantages including high precision, wide bandwidth, flexible reconfigurability, small size and low power consumption.

University of Ottawa
Designer: Weifeng Zhang | wzhan088@uottawa.ca
Professor: Jianping Yao | jpyao@site.uottawa.ca

Technology: Silicon Photonics – Passive Silicon on Insulator Training

Examples of projects using NSERC CREATE Si-EPIC (Silicon Electronic-Photonic Integrated Circuits Program)

AMF SOI

- A 0 40 GHz Silicon Photonic Integrated RF Receiver with Low Phase Noise Characteristics
  Institut national de la recherche scientifique | Designer: Daniel Onori | Professor: José Azaña
- Design 2D-Grating Coupler Array for Efficient Coupling between Ring-Core Fibers and Photonic Chip
  Université Laval | Designer: Mai Banawan | Professor: Leslie Ann Rusch
- Design of Arrayed Waveguide Grating with Flap Top, Low Insertion loss
  McGill University | Designer: Deng Mao | Professor: David Plant
- Energy Preserving All Pass Filter Based High Speed NOT Gate
  Institut national de la recherche scientifique | Designer: Saket Kaushal | Professor: Jose Azana
- Generation of Quantum Entangled Photon Pairs on a MRR
  University of British Columbia | Designer: Abdelrahman Afifi | Professor: Lukas Chrostowski
- Microwave Photonic Delay-line Filter Based on Balanced Side-Coupled Integrated Spaced Sequence of Resonators
  University of Ottawa | Designer: Jingsong Wu | Professor: Jianping Yao
- MIR Raman Laser
  Université Laval | Designer: Amin Khorshidahmad | Professor: Leslie Rusch
- MIR Raman Laser
  Université Laval | Designer: Mohammad Ahamdi | Professor: Sophie Larochelle
- Monolithically Integrated Silicon-Based Lasers and Amplifiers via Post-Process Oxide Etching and Rare-Earth Thin Film Deposition
  McMaster University | Designer: Cameron Naraine | Professor: Jonathan Bradley
- On-chip Fourier-transform Spectrometers Using TE and TM Modes
  Université Laval | Designer: Huijie Wang | Professor: Wei Shi
- On-Chip Quantum Manipulation and Characterization through Silicon Photonics
  University of Toronto | Designer: Meng Lon Iu | Professor: Amr Helmy
- Photonic Generation of Linearly Chirped Microwave Waveform in Cascaded Grating-coupled Microring Resonators
  University of Ottawa | Designer: Cheng Li | Professor: Jianping Yao
- Two-stage Filtering Residue Recovery for Efficient Bandwidth Allocation
  Université Laval | Designer: Jonathan Cauchon | Professor: Wei Shi

MEMS

Technology: MEMS Integrated Design for Inertial Sensors (MIDIS™) Platform

Teledyne DALSA MIDIS™

Development of High-performance Accelerometers Based on Nonlinear Internal Coupling

Applications include: Aerospace, Automotive, Entertainment

Our main goal is to explore feasibility of application of a well-known nonlinear 2:1 internal resonance phenomenon in improving performance of inertial sensors particularly accelometers. The micro-resonator is designed in a way to establish a 2:1 frequency ratio between desired modes shapes. The dimensions of the structure have to be determined through Finite Element Analysis (FEA), in ANSYS or CoventorWare, to make sure there exists a 2:1 frequency ratio between two desired structural modes. The intended application of the fabricated design is a capacitive nonlinear accelometers operating based on nonlinear 2:1 internal resonance. To activate this nonlinear phenomenon through electrostatic forces, a large amount of driving forces is normally needed. One of the desired characteristics of MIDIS process for our purpose is 1.5 um minimum feature size of device/structure layer. This can help us in a way to activate the nonlinear mechanism with less amount of driving levels, i.e., AC voltage. Another feature which is of great help is possibility of the device operation under vacuum. This eases the experimental procedures in terms of the amount of time needed to vacuum the testing chamber by a pump in the lab. All in all, it has been proven to us during the past two years that MIDIS process is the best choice among other processes. This is mainly due to the fact that we could successfully have our ideas implemented with the unique characteristics of this process.

Simon Fraser University
Designer: Bhargav Gadhvi | bgadhavi@sfu.ca
Professor: Behraad Bahreyni | bahreyni@sfu.ca

Teledyne DALSA MIDIS™

Micromachined Gyroscopes Based on Frequency Modulation

Applications include: Defence (Safety, Security)

Micromachined Gyroscopes Based on Frequency Modulation.

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

Technology: PiezoMUMPs

MEMSCAP PiezoMUMPS

Contour Mode Resonator (CMR)

Applications include: ICT (wireless transceiver applications)

The project is a part of my PhD thesis which will be defended at university of Waterloo. The design includes the CMR resonators and filters based on PiezoMUMPs process. The objective is measuring the designed chips and comparing with FEM simulation results.

University of Waterloo
Designer: Arash Fouladi Azarnaminy | a2foulad@uwaterloo.ca
Professor: Raafat Mansour | rrmansour@uwaterloo.ca

MEMSCAP PiezoMUMPS

Design Automation of Piezoelectric MEMS Harvester

Applications include: Natural Resource/Energy

During the last decade, energy harvesting from ambient has been recognized as a feasible method for powering the low-power electronic applications. In the literature, several attempts have been made to offer high-efficient piezoelectric MEMS harvesters. However, most of the introduced methodologies are dependent on designers’ decision. Therefore, in this study we propose the design automation technique for piezoelectric MEMS energy harvesters based on artificial intelligence. In this regard, deep learning technique is implemented to model a piezoelectric MEMS harvester, thus, the model can be utilized for optimization purpose. In order to verify ability of our proposed optimization methodology, the optimized harvester needs to be fabricated. As a result, the prototype measurement results will be used to show that this new optimization methodology can be considered as a feasible method for performance enhancing of the piezoelectric MEMS energy harvesters.

Memorial University of Newfoundland
Designer: Seyedfakhreddin Nabavi | snabavi@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

MEMSCAP PiezoMUMPS

Electrode Configuration Impacts on Performance of MEMS Harvester

Applications include: ICT (energy harvesting)

The conventional micro-electromechanical system (MEMS) energy harvesters can only generate voltage disadvantageously in a narrow bandwidth at higher frequencies. In this paper we propose a piezoelectric MEMS harvester with the capability of vibrating in multi-degree-of-freedom, whose operational bandwidth is enhanced by taking advantage of both multimodal and nonlinear mechanisms. The proposed harvester has a symmetric structure with a doubly clamped configuration enclosing three proof masses in distinct locations. Thanks to the uniform mass distribution, the energy harvesting efficiency can be considerably enhanced. To determine the optimum geometry for the preferred nonlinear behavior, we propose an automated design and optimization methodology based on the genetic algorithm (GA). By using the micromachining process, our optimized harvester with a total volume of 4.1 mm3 can be fabricated and measured.

Memorial University of Newfoundland
Designer: Seyedfakhreddin Nabavi | snabavi@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

MEMSCAP PiezoMUMPS

Electrostatic Actuator for Piezoelectric Micromachined Ultrasound Transducers (pMUTs)

Applications include: Health/Biomedical

An electrostatic actuator for piezoelectric micromachined ultrasound transducers (pMUTs) will be implemented. It will allow dynamic activation and deactivation of pMUTs. A previous version has been fabricated and tested with highly promising results. For this run significant modifications have been made and it is believed that the improved architecture will allow a faster and more reliable response.

Université du Québec à Montréal
Designer: Alexandre Robichaud | robichaud.alexandre@courrier.uqam.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

MEMSCAP PiezoMUMPS

Energy Harvesting from the Environment

Areas of application include: Natural Resource/Energy, Health/Biomedical, Environment

Working toward the improvement of energy harvesting technology. Nonlinear and multi modes designs are hard to simulate due to their nature. New designs using both of these phenomena have been created, fabrication will allow us to validate their operation. Tuning resonator is also usually impossible after fabrication. One of the proposed designs should allow modification of the resonant frequency in real time.

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

MEMSCAP PiezoMUMPS

Fatigue Study of Piezoelectric Harvester

Applications include: ICT (energy harvesting)

In this study, we propose a new curve-shaped anchoring scheme to improve the durability and energy conversion efficiency of the piezoelectric MEMS harvesters. In this regard, a doubly clamped curve beam with a mass at its center is considered as an anchor, while a straight beam with proof mass is integrated to the center of this anchor. To the best of our knowledge, thus far no study has been done to assess the fatigue damage, which is critical to the micro-sized silicon-based piezoelectric harvesters. We have utilized the Coffin-Manson method and finite element modeling (FEM) to comprehensively study the fatigue lifetime of the proposed geometry. By using a micro-fabrication process, we would be able to examine the capability of the proposed harvester in harnessing the vibration energy experimentally.

Memorial University of Newfoundland
Designer: Seyedfakhreddin Nabavi | snabavi@mun.ca
Professor: Lihong Zhang | lzhang@mun.ca

MEMSCAP PiezoMUMPS

High Sensitivity Gas Sensors Based on SAW Resonators and Micro Heaters

Applications include: ICT (industrial applications, environment/air/quality monitoring, on demand ventilation systems, smoke detectors)

The goal of this phase of the project is to implement a combined sensor utilizing both a SAW resonator and a micro-heater to measure the frequency and resistance change at the same time, and therefore combine the advantages of both sensing mechanisms. This is expected to increase the sensor's sensitivity and selectivity, which allows the discrimination between closely related analytes, while reducing the sensor hysteresis.

McGill University
Designer: Yu Zheng | yu.zheng3@mail.mcgill.ca
Professor: Mourad El-Gamal | mourad.el-gamal@mcgill.ca

MEMSCAP PiezoMUMPS

Isolation Platform for Widening Operating Temperature Range

Applications include: Health/Biomedical, Environment, ICT

Working towards the improvement of the operating temperature of dies, the proposed design is an isolation platform consisting of a platform suspended by various cantilevers and other supports geometries designed to achieve low heat transfer. New architectures to achieve these specifications have been developed to widen the operating temperature range of dies. The design aims to validate a thermal model for devices that we have created in order to decrease the energy transmission across the platform. The original application is to allow the cooling of some laser dies for aerospace applications.

Université du Québec à Montréal
Designer: Abdul Hafiz Alameh | alameha@hotmail.com
Professor: Frederic Nabki | frederic.nabki@sparkmicro.com

MEMSCAP PiezoMUMPS

Microactuator for Thermal Flow Control

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

This project aims to study the design and development of a microelectromechanical system (MEMS) capable of controlling the thermal power flow from a surface to another acting as an active temperature controller that will increase dramatically the range of temperature that a system can operate. This MEMS can be applied in multiple applications where the space, energy and temperature are critical parameters to consider in operation, contributing a novel temperature controller that will advance the state-of-the-art, in comparison with existing systems that typically implies high costs and complex operation. Different structures consisting of domes, fixed beams and other geometries, are designed to evaluate the behavior in a wide range of temperatures and thermal flows and define the best design that satisfies the requirements of this application.

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

MEMSCAP PiezoMUMPS

Microelectromechanical Systems (MEMS) Integration in Micromixers

Applications include: Health/Biomedical, Environment

Many micromixers found in literature use external actuators to achieve mixing. The primary objective of this design is to miniaturize active micromixers used for microfluidics. PiezoMUMPs was chosen to show that we can cost-effectively make use of industrial MEMS technologies to achieve hybrid active and passive micromixers based on polymer and silicon technologies.

Université du Québec à Montréal
Designer: Simon Dallaire | dallaire.simon@courrier.uqam.ca
Professor: Paul-Vahe Cicek | cicek.paul-vahe@uqam.ca

MEMSCAP PiezoMUMPS

MEMS Actuators for Optical Fiber Micro Alignment

Applications include: ICT

We are requesting CMC resources to test novel electrostatic MEMS actuator designs integrable with optical fibers for micro alignment of optical fibers with waveguides on the same chip. Our MEMS designs consists of a central platform capable of bi-directional motion along one or two axes. Integration of this platform with optical fibers shall enable micro alignment of the fibers with waveguides on the substrate along the two axes. This micro alignment stage will minimize the optical losses caused due to planar misalignment between optical fibers and waveguides. The resources requested now are to demonstrate and optimize different MEMS actuator designs that will be integrated with the optical structures once their performance has been proven satisfactory. Electrostatic actuation achieved through the comb drive and parallel plate designs is used to realise the planar motion of the suspended platform. The serpentine spring structure in one set of designs is responsible for micro alignment of optical fibers along one axis. The novel oval shaped springs designed for the other sets of designs enables micro alignment between fibers and waveguides along two axes providing complete planar alignment.

École de technologie supérieure
Designer: Suraj Sharma | suraj.sharma.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

MEMSCAP PiezoMUMPS

MEMS Actuators for Reconfigurable Silicon Photonics

Applications include: ICT

We requested CMC resources to develop novel electrostatic MEMS actuators integrable with optical waveguides and filters such as Bragg gratings and ring resonators on the same chip. The MEMS platform designed can be displaced in two directions to choose between different waveguides forming an optical switch. Upon integration with optical filters the same platform can be used as a wavelength channel selection system for photonics applications. Previously designed MEMS devices using this technology were based upon rotational motion using electrostatic actuation and resulted in state-of-the-art rotational MEMS devices for optical applications (Briere et al. 2017). These designs will use bi-directional motion using electrostatic actuation achieved through different comb drive and parallel plate actuator designs that will enable lateral and longitudinal motion of the suspended platform instead of rotation. While the lateral motion will enable switching action between different waveguides, the longitudinal motion of the central platform will enable gap closing between waveguides on the platform and the substrate. A combination of single and dual comb drive designs with different spring systems consisting of single beam support and serpentine spring structures will enable us to develop the ideal MEMS platform with high fill factor and low actuation voltage for waveguide integration. The resources requested will demonstrate and optimize different MEMS actuator designs which will be integrated with silicon nitride waveguides and optical filters using our own custom process flow once their performance has been proven satisfactory.

École de technologie supérieure
Designer: Suraj Sharma | suraj.sharma.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

MEMSCAP PiezoMUMPS

MEMS Piezoelectric Energy Harvester for Underwater Wireless Communications

Applications include: Environment, ICT

The main goal is to develop an autonomous optical wireless sensor node. The proposed design is an optimized piezoelectric vibration energy harvester consisting of cantilevers and other vibrating geometries designed to achieve low resonant frequencies, wide bandwidths and high power outputs based on the designs validated in runs IMPQMAA4 and IMPQMAA5 in order to increase the energy transduction coefficient and tailor the operating frequency range to targeted applications.

Université du Québec à Montréal
Designer: Abdul Hafiz Alameh | alameha@hotmail.com
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

MEMSCAP PiezoMUMPS

MEMS Tunable Ring Resonators

Applications include: ICT

We are requesting CMC resources to develop novel electrostatic MEMS actuators integrable with movable ring resonators on the same chip to form a MEMS tunable optical filter for photonics applications. Electrostatic actuation achieved through single and dual comb drive designs will enable lateral motion of the suspended platform. While single comb drive design will be responsible for the best fill factor, dual comb drive designs shall enable low voltage actuation. These MEMS designs will change the air gap between the fixed and suspended ring resonators from ~3µm to a few nm. This motion enables optical tuning between suspended and fixed ring resonators through MEMS. The resources requested right now are to demonstrate and optimize different MEMS actuator designs that will be integrated with optical filters once their performance has been proven satisfactory.

École de technologie supérieure
Designer: Suraj Sharma | suraj.sharma.1@ens.etsmtl.ca
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

MEMSCAP PiezoMUMPS

On-chip MEMS Based Tunable Laser

Applications include: ICT

The project is targeting the realization of a tunable laser, in a low cost and integrated version, with a wide tunability. By circumventing some limitations of tunable diode lasers, it will both leverage and enhance optical networks, in particular for datacenters. In order 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 which is changing 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, we are designing electrostatic MEMS as comb drive actuators to provide the required displacement of the input waveguide supported by a cantilever beam. In addition, we are also designing magnetic actuators based on the Lorentz force, which will be realized using the same process, for testing specific devices.

Concordia University
Designer: Mehdi Kharazmi | m_kharaz@encs.concordia.ca
Professor: Muthukumaran Packirisamy | pmuthu@alcor.concordia.ca

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MEMSCAP PiezoMUMPS

Optimization of a Strain Sensor Based on Resistive and Displacement Method

Applications include: Aerospace, ICT (material engineering)

The goal is to optimize a novel type of MEMS strain 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 1 um to 40µm.

Université du Québec à Montréal
Designer: Philippe-Olivier Beaulieu | philippe-olivier_beaulieu@hotmail.com
Professor: Frédéric Nabki | frederic.nabki@etsmtl.ca

MEMSCAP PiezoMUMPS

Piezoelectric Resonators and Filters

Applications include: ICT

Design includes contour mode piezoelectric resonators and filters based on PiezoMUMPs process. The objective is to fabricate high-Q resonators and narrow band filters with lowest possible insertion loss.

University of Waterloo
Designer: Arash Fouladi Azarnaminy | a2foulad@uwaterloo.ca
Professor: Raafat Mansour | rrmansour@uwaterloo.ca

MEMSCAP PiezoMUMPS

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 2.8 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

Technology: PolyMUMPs

MEMSCAP PolyMUMPs

Butterfly Gyroscope

Applications include: Aerospace, Automotive, Entertainment

Proposing an innovate design inspired by nature. Design consist of four proof-masses attached to a synchronizing beam. Angular rate is detected due to the change in capacitance.

University of Windsor
Designer: Nabeel Khan | khan187@uwindsor.ca
Professor: Jalal Mohammed Ahamed | jahamed@uwindsor.ca

MEMSCAP PolyMUMPs

CMUT Based Particulate Matter Sensors

Areas of application include: Environment, Health/Biomedical

The goal of the project is to implement a particulate matter sensor, based on Capacitive Micromachined Ultrasonic Transducers (CMUTs). The fabricated CMUT array will be used to detect mass loading effect on deposition of particulate matter. The transducer will resonate at a frequency of 2.8 MHz. The resonance frequency is dependent on the physical dimensions of the resonating circular membrane, and these dimensions are dedicated for sensing the deposition of mass on the membrane. An array of CMUTs 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 PolyMUMPS 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

MEMSCAP PolyMUMPs

Higher Reflectivity Micormirror with Less Dimples

Applications include: ICT (HUD applications)

This application is to use PolyMUMPS to fabricate 2D micromirror for laser display. Our group had successfully developed PolyMUMPS micromirror integrated with melting beams to solve the stiction problem. The present application is to develop micromirror with less dimples to increase the reflectivity of the mirror in by integrating the post-fabrication melting beams. With the aid of melting beams, the mirror plate can survive during the wet releasing with dimples only in the center area of the mirror plate to prevent stiction during operation. This is because the mirror plate is curved as a bowl shape due to the residual stress. We apply for two dies space to test the size of area required the dimples.

Ryerson University
Designer: Hui Zuo | hui.zuo@ryerson.ca
Professor: Siyuan He | s2he@ryerson.ca

MEMSCAP PolyMUMPs

Highly Integrated MEMS Resonators for Gas Sensing

Applications include: Agriculture/Agri-Food, Defence (Safety, Security), Environment, Health/Biomedical

This project aims to study the design and development of a microelectromechanical system (MEMS) capable of detecting gases at low concentrations in a controlled and open atmosphere. This sensor will leverage the resonance frequency shift of a resonating micro-structure (i.e., MEMS resonator) in the presence of gas molecules, contributing a novel sensor that will advance the state-of-the-art, that typically implies high costs and complex operation. Different structures consisting of cantilevers, fixed beams and other resonating geometries, are designed to evaluate the behavior in the presence of a wide range of gas concentrations and define the best design that satisfies the requirements of this applications.

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

MEMSCAP PolyMUMPs

MEMS Gas and Chemical Sensors

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

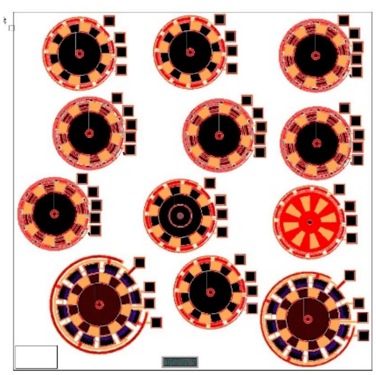
A novel bifurcation gas and chemical sensors have been designed to detect toxic gases in the air and mercury in water. A polymeric sensing material will be used to enhance the sensor sensitivity. PolyMUMPs fabrication process will be used to validate many experimental to proof the sensor functionality.

University of Waterloo
Designer: Mohamed Arabi | msaaarab@uwaterloo.ca
Professor: Mustafa Yavuz | myavuz@uwaterloo.ca

MEMSCAP PolyMUMPs

MEMS Micromotor for Optical Swept Filters

Applications include: Health/Biomedical



The designs proposed are related to microoptoelectromechanical 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 an 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

MEMSCAP PolyMUMPs

MEMS Sensors and Transducers

Applications include: Health/Biomedical

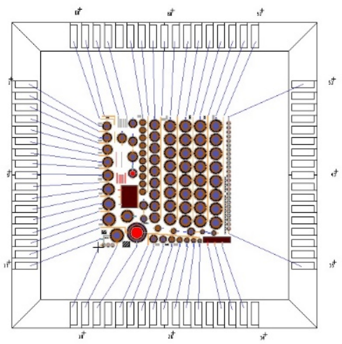
MEMS Sensors and Transducers, CMUT and M3CMUT transducers.

University of Windsor
Designer: Haleh Nazemi | nazemih@uwindsor.ca
Professor: Arezoo Emadi | arezoo.emadi@uwindsor.ca

MEMSCAP PolyMUMPs

MEMS Ultrasonic Transducers for Space Application (with Cornell and NASA)

Applications include: Aerospace



Air Coupled moving membrane transducers for imaging on MARS in collaboration with Cornell University and The National Aeronautics and Space Administration (NASA)

University of Manitoba
Designer: Mayank Thacker | thacker5@myumanitoba.ca
Professor: Douglas Buchanan | douglas.buchanan@umanitoba.ca

MEMSCAP PolyMUMPs

Occupancy Detection Using CMUTS Phased Arrays

Applications include: ICT, Health/Biomendial (occupancy detection, non-destructive testing, and medical imaging)

Ultrasonic transducers are seeing widespread use in a wide range of applications. Piezoelectric transducers have been the main type used in ultrasonics. However, capacitive-based transducers are currently attracting significant interest. A unique advantage over their piezoelectric counterpart lies in their lower mechanical impedance, offering the potential for a better impedance match with low-density fluid media such as air. The operation of capacitive transducers is also less sensitive to temperature. There has been intensive research and increasing interest towards capacitive micromachined ultrasonic transducers (CMUTs) as they are usually integrated closely with their interface electronic circuits, forming complete standalone small size systems. Our research team has a wide experience in designing, simulating, manufacturing, and testing micromachined ultrasonic probes. Operation in air has been tested for ranging applications in previous work. In addition, postprocessing for CMUTs fabricated in previous PolyMUMPS runs was developed for underwater testing. This enabled us to use CMUTs fabricated in the PolyMUMPS technology for nondestructive testing applications. However, all previous trials of our team have been in creating a single element of CMUT. The goal of this phase of the project is to implement a CMUT phasedarray in a commercial surface micromachining process. This array will be targeted for occupancy detection applications that are seeing a big interest in the smart home sector, especially for very lower power implementations.

McGill University
Designer: Hani Tawfik | hani.tawfik@mail.mcgill.ca
Professor: Mourad El-Gamal | mourad.el-gamal@mcgill.ca

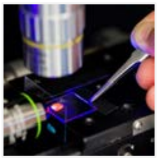
MEMSCAP PolyMUMPs

Two-dimensional Micro-hotplate Platforms for Printed Gas Sensors

Applications include: ICT (VOC gas sensing is applied for air quality measurement ranging from indoor air condition monitoring to gas leakage detecting in the oil industry)

The goal of this project is to extend the studies from the previous design (1801MU) and further optimize the performance of the fabricated micro-hotplates. In the previous design, we utilized the advantage of PolyMUMPS' multi-layer structure to fabricate micro-hotplate with a heater (Poly0), insulating layers (Oxide1, Oxide2) and sensing electrodes (Poly1, Poly2). After proper in-house post-processing steps, the fabrication of micro-hotplates through PolyMUMPs technology was demonstrated. In the next design, we are planning to further optimize the design by exploring the feasibility of utilizing the polysilicon layer (Poly2) as a heat distributor. The design will be targeting the realization of micro-hotplates exhibiting low power consumption and uniform temperature distribution.

McGill University
Designer: Yu-Cheng Cho | yu-cheng.cho@mail.mcgill.ca
Professor: Mourad El-Gamal | mourad.el-gamal@mcgill.ca

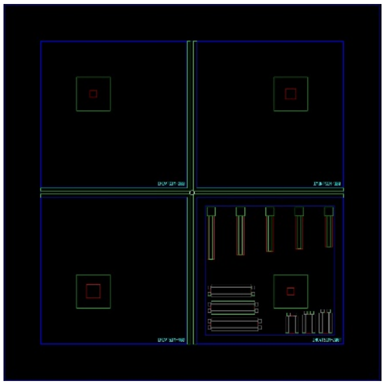


Technology: SOIMUMPs

MEMSCAP SOIMUMPs

Membrane for use in Fabry-Perot Harsh Environment Pressure Sensing

Applications include: Aerospace, Automotive, ICT (manufacturing)



Development of a harsh environment membrane pressure sensor for use with Fabry-Perot optical interference interrogation. The primary objective of the device is to be used in high pressure and temperature environments for industrial process monitoring and optimization. Additional structures are included for testing of elastic modulus and residual stress using electrostatic pull-in behavior.

University of Waterloo
Designer: Eric Brace | ejbrace@uwaterloo.ca
Professor: Patricia Nieva | pnieva@uwaterloo.ca

MNT (Micro-Nano Technology) FABRICATION

CMC's MNT Portal - www.cmc.ca/MNT - includes more than **40** MNT facilities located at universities across Canada offering custom fabrication - mask generation, etching, materials deposition, lithography, and characterization. This report describes designs that concluded in 2018/19 and benefited from CMC's MNT Portal financial assistance.

MNT: Characterization

- Characterization of high temperature superconductor coated conductors | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Jean-Hughes Fournier Lupien | E: j-h.fournier@polymtl.ca
  Professor: Frederic Sirois | E: f.sirois@polymtl.ca

- Cavity microwave resonators coupled to flexible, superconducting NbSe2 membranes: electromechanical circuits in the quantum regime | Lab: NFK
  Queen's University
  Designer: Kurt Tyson | E: 12kht1@queensu.ca
  Professor: Robert Knobel | E: knobel@queensu.ca

- Patterned deposition of polymer semiconductors from subcritical fluids | Lab: 4D LABS
  Simon Fraser University
  Designer: Nastaran Yousefi | E: nyousefi@sfu.ca
  Professor: Loren Kaake | E: lkaake@sfu.ca

MNT: MEMS

- 3 degree of freedom MEMS optical platform and mirror | Lab: Nano Systems Fabrication Laboratory (NSFL)
  University of Manitoba
  Designer: Elnaz Afsharipour | E: afsharie@myumanitoba.ca
  Professor: Cyrus Shafai | E: cyrus.shafai@umanitoba.ca

- A high-transmit-sensitivity circular capacitive micromachined ultrasonic transducer (CMUT) array for non-destructive testing applications | Lab: Giga-to-Nanoelectronics (G2N)
  University of Waterloo
  Designer: Tirad Owais | E: taowais@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- A passive wireless low range capacitive pressure sensor system for sleep apnea detection | Lab: Advanced Materials and Process Engineering Laboratory (AMPEL)
  University of British Columbia
  Designer: Hamed Pouriayevali | E: hpouria@mail.ubc.ca
  Professor: Boris Stoeber | E: stoeber@mech.ubc.ca

- Design and development of novel MEMS based wireless temperature sensor for in-vivo biomedical application | Lab: Advanced Materials and Process Engineering Laboratory (AMPEL)
  University of British Columbia
  Designer: Ronish Patel | E: rpatel@ece.ubc.ca
  Professor: Kenichi Takahata | E: takahata@ece.ubc.ca

- Design and fabrication of high-efficiency mutual inductors based on rolled-up SiOx/SiNx microtubes | Lab: Toronto Nanofabrication Centre (TNFC)
  McGill University
  Designer: Ran Peng | E: pengran406@gmail.com
  Professor: Xinyu Liu | E: xyliu@mie.utoronto.ca

- Design and fabrication of MEMS based sensing rosette for quantifying the influence of strained silicon on the piezoresistivity | Lab: NanoFab
  University of Alberta
  Designer: Amr Balbola | E: balbola@ualberta.ca
  Professor: Walied Moussa | E: walied.moussa@ualberta.ca

- Design of a coupled electro-mechanical radial tester for stretchable electronics | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Yang Li | E: yang.li@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Design and development of a novel MEMS Gyroscope with high Q-factor by combining the electrostatic attraction and repulsion forces to match the drive and sensing frequencies | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Windsor
  Designer: Imran Khan | E: khan1cm@uwindsor.ca
  Professor: Jalal Mohammed Ahamed | E: jahamed@uwindsor.ca

- Development of a MEMS device for core shell silicon nanowire mechanical characterization | Lab: Toronto Nanofabrication Centre
  University of Toronto
  Designer: Changchong Cao | E: c.cao@mail.utoronto.ca
  Professor: Yu Sun | E: sun@mie.utoronto.ca

- Development of a MEMS device for measuring contractile force of cardiomyocyte | Lab: Toronto Nanofabrication Centre
  University of Toronto
  Designer Name(s): Li Wang | E: liwhz.wang@utoronto.ca
  Professor: Yu Sun | E: sun@mie.utoronto.ca

- Development of a micro-scale two-point shear bridge test to evaluate a MEMS stress sensor performance | Lab: NanoFab
  University of Alberta
  Designer: Amr Balbola | E: balbola@ualberta.ca
  Professor: Walied Moussa | E: walied.moussa@ualberta.ca

- Development of a temperature compensation system for piezoresistive 3D stress sensor | Lab: NanoFab
  University of Alberta
  Designer: Mohammed Kayed | E: mkayed@ualberta.ca
  Professor: Walied Moussa | E: walied.moussa@ualberta.ca

- Development of RF MEMS process on Low Temperature Co-fired Ceramic (LTCC) technology | Lab: Centre for Integrated RF Engineering (CIRFE)
  École de technologie supérieure
  Designer: Dorra Bahloul | E: bahloul.dorra@gmail.com
  Professor: Ammar Kouki | E: ammar.kouki@etsmtl.ca

- Development of self-healed electrolyte-gated organic transistors | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Yang Li | E: yang.li@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Directional IR sensor | Lab: 4D LABS
  Simon Fraser University
  Designer: Siamack V. Grayli | E: svgrayli@sfu.ca
  Professor: Behraad Bahreyni | E: behraad_bahreyni@sfu.ca

- EEG microneedles dry electrode for sleep apnea monitoring | Lab: Advanced Materials and Process Engineering Laboratory (AMPEL)
  University of British Columbia
  Designer: Jorge Lozano | E: jlozano@ece.ubc.ca
  Professor: Boris Stoeber | E: stoeber@mech.ubc.ca

- Electromagnetic low voltage MEMS adaptive optics mirror system | Lab: Nano Systems Fabrication Laboratory (NSFL)
  University of Manitoba
  Designer: Byoungyoul Park | E: parkb3@myumanitoba.ca
  Professor: Cyrus Shafai | E: cyrus.shafai@umanitoba.ca

- Engineered ground micromachined CPW resonator for distant coupling with a tag over a MEMS membrane for zero power biomedical sensing applications | Lab: NanoFab
  University of Alberta
  Designer: Masoud Baghelani | E: baghelan@ualberta.ca
  Professor: Mojgan Daneshmand | E: mojgan@ece.ualberta.ca

- Enhanced process for rapid prototyping SAW devices | NanoFabrication Kingston (NFK)
  Queen's University
  Designer: Edward Muzar | E: emuzar@physics.queensu.ca
  Professor: James Stotz | E: jstotz@queensu.ca

- Fabricating an ionic liquid-based electrospray ion thruster for miniaturized satellite | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Ben George | E: ben-t.george@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Fabrication and Packaging of Multi-axis MEMS Tactile Sensor array | Lab: NanoFab
  University of Alberta
  Designer: Shichao Yu | E: shichao2@ualberta.ca
  Professor: Walied Moussa | E: walied.moussa@ualberta.ca

- Fabricating Emitter Array for a Miniature Satellite Ion Thruster | Lab: GCM Lab
  Polytechnique Montréal
  Designer: JeeYeon Yeu | E: yeu.jee@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Fabrication of 1D repulsive force scanning micromirrors on SOI wafer | Lab: Toronto Nanofabrication Centre (TNFC)
  Ryerson University
  Designer: Vixen Tan | E: vjtan@ryerson.ca
  Professor: Siyuan He | E: s2he@ryerson.ca

- Fabrication of a multi-frequency CMUT for microparticle manipulation | Lab: Giga-to-Nanoelectronics (G2N)
  University of Waterloo
  Designer: Zhou Zheng | E: z57zheng@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- Fabrication of thinner mirror plates for high frequency scanning FPCB micromirrors | Lab: Toronto Nanofabrication Centre (TNFC)
  Ryerson University
  Designer: Mehraz Haque | E: mehraz.haque@ryerson.ca
  Professor: Siyuan He | E: s2he@ryerson.ca

- Frequency modulating device using suspended microstring of vanadium dioxide-based phase changing material by optical and electrical stimulus | Lab: NanoFab
  University of Alberta
  Designer: Syed Bukhari | E: smanzoor@ualberta.ca
  Professor: Hyun-Joong Chung | E: chung3@ualberta.ca

- Highly sensitive microwave circuits for light and gas detection | Lab Nanofab
  University of British Columbia
  Designer: Benjamin Wiltshire | E: benjamin.wiltshire@alumni.ubc.ca
  Professor: Mohammad Zarifi | E: mohammad.zarifi@ubc.ca

- Investigation of multi-excitation entropy model in organic field effect transistors | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Zhaojing Gao | E: zhaojing.gao@polymtl.ca
  Professor: Clara Santato | E: clara.santato@polymtl.ca

- Label-free Hormone Detection: An Integrated Sample-to-Analysis Lab on a Chip System | Lab: NanoFabrication Kingston (NFK)
  Carleton University, Queen's University
  Designer: Roslyn Massey | E: 12rm61@queensu.ca
  Professor Name: Ravi Prakash | E: ravi.prakash@queensu.ca | E: raviprakash@cunet.carleton.ca

- Lateral 2D SOI micromirror fabrication | Lab: Toronto Nanofabrication Centre (TNFC)
  Ryerson University
  Designer: Hui Zuo | E: hui.zuo@ryerson.ca
  Professor: Siyuan He | E: s2he@ryerson.ca

- Mechanisms of amyloid- beta-induced synaptic dysfunction | Lab: Microsystems Hub
  University of Calgary
  Designer: Masoud Pahlevaninezhad | E: masoud.pahlevaninezh@ucalgary.ca
  Professor: Amir Sanati Nezhad | E: amir.sanatinezhad@ucalgary.ca

- MEMS gyroscope | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Windsor
  Designer: Imran Khan | E: khan1cm@uwindsor.ca
  Professor: Jalal Mohammed Ahamed | E: jahamed@uwindsor.ca

- NbSe2 and MoS2 membranes: electromechanical circuits and optics in the quantum regime | Lab: NanoFabrication Kingston (NFK)
  Queen's University
  Designer: Kurt Tyson | E: 12kht1@queensu.ca
  Professor: Robert Knobel | E: knobel@queensu.ca

- Opto-electrochemical sensors for rapid deposit detection in water for industrial equipment | Lab: CoFaMIC
  Université du Québec à Montréal
  Designer: Philippe Descent | E: descent.philippe@courrier.uqam.ca
  Professor: Paul-Vahe Cicek | E: cicek.paul-vahe@uqam.ca

- Patterning of device using hydrothermally grown SnO2 nanorods for electrolyte gated transistors | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Arunprabaharan Subramanian | E: arunprabaharan.subramanian@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Photonic crystal process for SAW devices | Lab: NanoFabrication Kingston (NFK)
  Queen's University
  Designer: Edward Muzar | E: emuzar@physics.queensu.ca
  Professor: James Stotz | E: jstotz@queensu.ca

- Resonant DC electric field sensor | Lab: Nano Systems Fabrication Laboratory (NSFL)
  University of Manitoba
  Designer: Selva Murugesan | E: murugesp@myumanitoba.ca
  Professor: Cyrus Shafai | E: cyrus.shafai@umanitoba.ca

- Stretchable electrodes for monitoring and stimulating neuromotor functions in small animals | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Nicolò Rossetti | E: nicolo.rossetti@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Study of dynamic mechanical properties and nanostructures of polyelectrolytes using microfluidic cantilevers and Kelvin force probe microscopy | Lab: NanoFab
  University of Alberta
  Designer: Rosmi Abraham | E: rosmi@ualberta.ca
  Professor: Hyun-Joong Chung | E: chung3@ualberta.ca

- Water salinity micro sensor | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Alaaeldin Ahmed | E: aesamymo@uwaterloo.ca
  Professor: Eihab Abdel-Rahman | E: eihab@uwaterloo.ca

- WO3 based electrolyte gated phototransistors | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Arunprabaharan Subramanian | E: arunprabaharan.subramanian@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

MNT: Microelectronics

- Characterization of nanoporous alumina membranes and ferromagnetic nanowires arrays for spin waves transducers | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Antoine Morin | E: antoine.morin@polymtl.ca
  Professor: David Menard | E: david.menard@polymtl.ca

- Creating a stretchable and reliable strain sensor using PEDOT:PSS/Ag NW hybrid films | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Jiaxing Huang | E: jiaxing.huang@mail.utoronto.ca
  Professor: Mohini Sain | E: m.sain@utoronto.ca

- Flexible organic electrochemical transistors making use of PEODT:PSS/nanocellulose composites | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Zhihui Yi | E: zhihui.yi@utoronto.ca
  Professor: Mohini Sain | E: m.sain@utoronto.ca

- Fracture strength of thin film materials at high temperatures under the influence of creep | Lab: Centre for Integrated RF Engineering (CIRFE)
  University of Waterloo
  Designer: Alex Axel Navarrete Gonzalez | E: aanavarr@uwaterloo.ca
  Professor: Patricia Nieva | E: pnieva@uwaterloo.ca

- Patterned deposition of polymer semiconductors from supercritical fluids | Lab: 4D LABS
  Simon Fraser University
  Designer: Nastaran Yousefi | E: nyousefi@sfu.ca
  Professor: Loren Kaake | E: lkaake@sfu.ca

- Supercapacitors made from PEDOT:PSS and activated carbon composites | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Xianyao Wang | E: xianyao.wang@mail.utoronto.ca
  Professor: Mohini Sain | E: m.sain@utoronto.ca

MNT: Microfluidics

- Embedded silver PDMS electrodes for single cell electrical impedance spectroscopy | Lab: Toronto Nanofabrication Centre
  University of Toronto
  Designer: Zhenxong Xu | E: zhensong.xu@mail.utoronto.ca
  Professor: Yu Sun | E: sun@mie.utoronto.ca

- Mechanisms of amyloid- beta-induced synaptic dysfunction | Lab: AMNF
  University of Calgary
  Designer: Masoud Pahlevaninezhad | E: masoud.pahlevaninezh@ucalgary.ca
  Professor: Amir Sanati Nezhad | E: amir.sanatinezhad@ucalgary.ca

- Microchip development for dielectrophoresis positioning single-cell impedance array for real-time drug screening | Lab: Nanofab
  University of Alberta
  Designer: Pedro Duarte | E: duarteri@ualberta.ca
  Professor: Jie Chen | E: jchen@ece.ualberta.ca

- Microfluidic device for wideband multi-frequency dielectrophoresis based characterization of single cells | Lab: Nano Systems Fabrication Laboratory (NSFL)
  University of Manitoba
  Designer: Ziang Wang | E: wangza@myumanitoba.ca
  Professor: Greg Bridges | E: gregory.bridges@umanitoba.ca

- Nickel porous catalyst layers | Lab: 4D LABS
  Simon Fraser University
  Designer: Audrey Taylor | E: audreyt@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

MNT: Micromachining

- Fabricating an ionic liquid-based electrospray ion thruster for 2020 PolyOrbite CubeSat mission | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Ben George | E: ben-t.george@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Fabrication of Janus particles for enhanced drug delivery applications | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Calgary
  Designer: Shabab Saad | E: shabab.saad@ucalgary.ca
  Professor: Giovanniantonio Natale | E: gnatale@ucalgary.ca

- Fabrication of electrodes for characterizing protein-based materials | Lab: McGill Nanotools Microfab (MNM)
  McGill University
  Designer: Saadia Wasim | E: saadia.wasim@mail.mcgill.ca
  Professor: Noémie-Manuelle Dorval Courchesne | E: noemie.dorvalcourchesne@mcgill.ca

- Fabrication stretchable conductors by electrospinning | Lab: Laboratory of Micro and Nanofabrication (LMN)
  Polytechnique Montréal
  Designer: Michael Lerond | E: michael.lerond@polymtl.ca
  Professor: Fabio Cicoira | E: fabio.cicoira@polymtl.ca

- Folded ridged half-mode waveguide bandpass and bandstop filters | Lab: NanoFab
  University of Alberta
  Designer: Thomas Jones | E: trjones@ualberta.ca
  Professor: Mogjan Daneshmand | E: mojgan@ece.ualberta.ca

- Monolithic integrated bandpass filters and leaky-wave antennas for next generation of mobile connectivity (5G) based on microfabricated 3D waveguides | Lab: NanoFab
  University of Alberta
  Designer: Qihui Zhou | E: qihui@ualberta.ca
  Professor: Mogjan Daneshmand | E: mojgan@ece.ualberta.ca

- Patterning the growth catalyst of Carbon Nanotube (CNT) forests for three-dimensional micro-Electro-Discharge-Machining (μ-EDM) experiments | Lab: Advanced Materials and Process Engineering Laboratory (AMPEL)
  University of British Columbia
  Designer: Mohab Hassan | E: mohab@ece.ubc.ca
  Professor: Kenichi Takahata | E: takahata@ece.ubc.ca

- Ridged half-mode waveguide bandpass filter | Lab: NanoFab
  University of Alberta
  Designer: Thomas Jones | E: trjones@ualberta.ca
  Professor: Mogjan Daneshmand | E: mojgan@ece.ualberta.ca

- Ridged half-Mode waveguide beamforming network | Lab: NanoFab
  University of Alberta
  Designer: Eric Der | E: der@ualberta.ca
  Professor: Mogjan Daneshmand | E: mojgan@ece.ualberta.ca

- Surface acoustic wave devices using ZnO overlayers | NanoFabrication Kingston (NFK)
  Queen's University
  Designer: Golnaz Azodi | E: gazodi@physics.queensu.ca
  Professor: James Stotz | E: jstotz@queensu.ca

- Transducer fabrication and growth optimization for piezoelectric ZnO overlayer | NanoFabrication Kingston (NFK)
  Queen's University
  Designer: Golnaz Azodi | E: gazodi@physics.queensu.ca
  Professor: James Stotz | E: jstotz@queensu.ca

MNT: Nanotechnology

- A Carbon nanotube field emission multi-pixel X-ray source for fluence field modulated computational tomography | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Elahe Cheraghi | E: echeragh@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- A multi-pixel x-ray source by carbon nano tube cold cathode field emission for CT imaging | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Jiayu Alexander Liu | E: jiayu.alexander.liu@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- Anodizing titanium transmission electron microscope grids for novel nanoscale imaging | Lab: Nanofab
  University of Alberta
  Designer: Ryan Kisslinger | E: kissling@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- "Black Gold" - Fabrication of nanostructured gold for plasmonic and nanophotonic applications | Lab: 4D LABS
  Simon Fraser University
  Designer: Albert Adserias | E: albert_adserias@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Cancer therapy from engineered gold nanoparticle-polymer drug nanocarriers | Lab: 4D LABS
  Simon Fraser University
  Designer: David Rider | E: david.rider@wwu.edu
  Professor: Bryon Gates | E: bgates@sfu.ca

- Carbon Nanotube Josephson Junction | Lab: Quantum NanoFab
  University of Waterloo
  Designer: HeeBong Yang | E: heebong.yang@uwaterloo.ca
  Professor Name: Na Young Kim | E: nayoung.kim@uwaterloo.ca

- Chemically modified graphitic carbon nitride (g-C3N4) framework for visible light driven dye degradation | Lab: Nanofab
  University of Alberta
  Designer: Pawan Kumar | E: pawan@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Chromium doped titania nanotubes and their photoresponse in visible light | Lab: Nanofab
  University of Alberta
  Designer: Najia Mahdi | E: nmahdi@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Conductive electrodes made from PEDOT:PSS based composite films | Lab: GCM Lab
  University of Toronto
  Designer: Shulin Feng | E: alexa.feng@mail.utoronto.ca
  Professor: Mohini Sain | E: m.sain@utoronto.ca

- Cross-pattern meta-surface enhanced carbon nanotubes/polymer composite for Terahertz room temperature imaging | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Mingyu Zhang | E: m265zhan@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- CVD growth and characterization of 2D materials for solar cell applications | Lab: 4D LABS
  Simon Fraser University
  Designer: M Bakhtiar Azim | E: mbazim@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Design and development of nanomaterials with superhydrophobic and superoleophobic properties | Lab: Nanofab
  University of Alberta
  Designer: Lian Shoute | E: lshoute@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Development of sustainable tannin-based micro-supercapacitors on a flexible substrate | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Clara Santato | E: clara.santato@polymtl.ca
  Professor: Julien Lemieux | E: julien.lemieux@polymtl.ca

- Dielectric layer characterization and fabrication | Lab: 4D LABS
  Simon Fraser University
  Designer: Sasan V. Grayli | E: sasanv@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Dielectric layer fabrication and performance | Lab: 4D LABS
  Simon Fraser University
  Designer Name(s): Sasan V. Grayli, sasanv@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Electrodeposition of ZnO thin films on heavily doped (1 1 1) silicon wafers | Lab: Nanofab
  University of Alberta
  Designer: Yun Zhang | E: yun10@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Electron beam lithography and scanning electron microscopy of high-quality superconducting quantum devices | Lab: Quantum NanoFab
  University of Waterloo
  Designer Name(s): Jiahao Shi | E: j85shi@uwaterloo.ca
  Professor: Adrian Lupascu | E: alupascu@uwaterloo.ca

- Electron beam lithography of high-quality superconducting quantum devices | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Muhamet Ali Yurtalan | E: mayurtal@uwaterloo.ca
  Professor: Adrian Lupascu | E: alupascu@uwaterloo.ca

- Enhancement of photocatalysis by integrating of plasmonic nanoparticle and microspherical shell TiO2 photonic crystals | Lab: Nanofab
  University of Alberta
  Designer: Yun Zhang | E: yun10@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Fabrication and Characterization of 2D MoS2 based Bipolar Junction Transistor for High Frequency Electronics | Lab: 4D LABS
  Simon Fraser University
  Designer: Abdelrahman Askar | E: aaskar@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Fabrication of 1D Bragg Reflector | Lab: Nanofab
  University of Alberta
  Designer: Qiwei Xu | E: qxu1@ualberta.ca
  Professor: Xihua Wang | E: xihua@ualberta.ca

- Fabrication of high-performance photodetectors using 2D materials | Lab: 4D LABS
  Simon Fraser University
  Designer: Amin Abnavi | E: amin_abnavi@sfu.ca
  Professor: Michael Adachi | E: mmadachi@sfu.ca

- Fabrication of multilayered plasmonic quantum metal structures | Lab: 4D LABS
  Simon Fraser University
  Designer: Sasan V. Grayli | E: sasanv@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Fabrication of novel chalcogenide nanomaterials and their use as high performance photocatalysts | Lab: Nanofab
  University of Alberta
  Designer: Piyush Kar | E: pkar1@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Fluoride free solid electrolyte for TiO2 nanotubes fabrication | Lab: Nanofab
  University of Alberta
  Designer: Arezoo Hosseini | E: hosseiniarezu1364@gmail.com
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Graphene-based FET fabrication for high sensitivity biosensing applications | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Inna Novodchuk | E: inovodch@uwaterloo.ca
  Professor: Mustafa Yavuz | E: myavuz@uwaterloo.ca

- Graphene-based room temperature terahertz detector | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Mingyu Zhang | E: m265zhan@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

- High mobility ZnO for high efficiency perovskite solar cells | Lab: Nanofab
  University of Alberta
  Designer: Ujwal Kumar Thakur | E: ujwal@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Hot hole injection from noble metal nanoparticles on nanoporous P-type nickel oxide films | Lab: Nanofab
  University of Alberta
  Designer: Ryan Kisslinger | E: kissling@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Integrated nano/bio platform for sensitive and high throughput detection of biological analytes | Lab: McGill Nanotools Microfab (MNM)
  McGill University
  Designer: Mahsa Jalali | E: mahsa.jalali@mail.mcgill.ca
  Professor Name: Sara Mahshid | E: sara.mahshid@mcgill.ca

- Lithographically prepared structured Ni electrodes for the oxygen evolution reaction | Lab: 4D LABS
  Simon Fraser University
  Designer: Ana Sonea | E: asonea@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Local state-of-charge and oxidation state mapping of a high voltage spinel cathode in solid state batteries | Lab: 4D LABS
  Simon Fraser University
  Designer: Jeffrey Ovens | E: jovens@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Manufacturing and testing of advanced multi-layer metal-oxide diodes incorporating transition metal dichalcogenides | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Abdullah Alshehri | E: a7alsheh@uwaterloo.ca
  Professor: Mustafa Yavuz | E: myavuz@uwaterloo.ca

- Nickel electrodes with inclusions for enhanced OER activity | Lab: 4D LABS
  Simon Fraser University
  Designer: Alexi Pauls | E: alexip@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Nano-mechanical characterization of freestanding graphene and other two-dimensional materials | Lab: Toronto Nanofabrication Centre
  University of Toronto
  Designer: Teng Cui | E: teng.cui@mail.utoronto.ca
  Professor: Yu Sun | E: sun@mie.utoronto.ca

- Nanoparticles with tunable surfaces for biomedical applications | Lab: 4D LABS
  Simon Fraser University
  Designer: Iris Guo | E: iguo@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Nanoporous P-Type nickel oxide films grown on non-native substrates for improved photovoltaics | Lab: Nanofab
  University of Alberta
  Designer: Ryan Kisslinger | E: kissling@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Nanostructured copper surfaces to control bacterial contamination | Lab: 4D LABS
  Simon Fraser University
  Designer: Michael Hemsworth | E: mhemswor@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Novel 2D nanomaterials used in gas sensing and breathalyzer applications | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Khaled Ibrahim | E: k4ibrahi@uwaterloo.ca
  Professor: Mustafa Yavuz | E: myavuz@uwaterloo.ca

- Optimizing photoelectrochemical water-splitting with p-type WO3 | Lab: Nanofab
  University of Alberta
  Designer: Ajay Manuel | E: apmanuel@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Optimizing plasmonic photocatalysis in bimetallic core-shell nanoparticle systems | Lab: Nanofab
  University of Alberta
  Designer: Ajay Manuel | E: apmanuel@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Phosphorous doped carbon nitride quantum dots (PCNQDs) decorated mixed rutile-anatase phase TiO2 for visible light induced hydrogen generation | Lab: Nanofab
  University of Alberta
  Designer: Pawan Kumar | E: pawan@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- (Photo)conductivity measurements of chemically controlled eumelanin for sustainable optoelectronics applications | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Manuel Reali | E: manuel.reali@gmail.com
  Professor Name: Clara Santato | E: clara.santato@polymtl.ca

- Photolithography and characterization of MoS2 based devices | Lab: Nanofab
  University of Alberta
  Designer: Dhanvini Gudi | E: gudi@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- Plasmon Enhanced SERS Detection of Small Molecules Using Anodically Formed Au-TiO2 Nanocomposites | Lab: Nanofab
  University of Alberta
  Designer: Najia Mahdi | E: nmahdi@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Plasmon-enhanced and spin-orbit coupling assisted water splitting by bismuth chalcogenide topological insulators | Lab: Nanofab
  University of Alberta
  Designer: Kazi Alam | E: kmalam@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Plasmon-enhanced square shaped rutile TiO_2 nanotubes for higher performance CO_2 photoreduction | Lab: Nanofab
  University of Alberta
  Designer: Ehsan Vahidzadeh | E: vahidzad@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca
- | Lab: 4D LABS
  Simon Fraser University
  Designer: Xiaoyun Yuan | E: xiaoyuny@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Rapid Electron Area Masking (REAM) lithography (Part 2) | Lab: 4D LABS
  Simon Fraser University
  Designer: Finlay MacNab | E: fma24@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Removal of heavy metals from polluted soil in an industrial site by plants: phytoremediation and environmental sustainability | Lab: 4D LABS
  Simon Fraser University
  Designer: Bouchra Belhaj Abdallah | E: bbelhaja@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Slot die coating of flexible transparent electrodes and solar cells | Lab: NanoQam
  École de technologie supérieure
  Designer: Vladimir Cornille | E: vladimir.cornille.1@ens.etsmtl.ca
  Professor: Ricardo Izquierdo | E: ricardo.izquierdo@etsmtl.ca

- Stability and efficiency enhancement of perovskite solar cells using carbon nitride quantum dots embedded in TiO_2 nanorods | Lab: Nanofab
  University of Alberta
  Designer: Ujwal Kumar Thakur | E: ujwal@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Surface modification of silica coated iron oxide nanoparticles for water purification | Lab: 4D LABS
  Simon Fraser University
  Designer: Henry Kang | E: hjkang@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Synthesis of all-inorganic lead-free cesium bismuth halide perovskite quantum dots | Lab: 4D LABS
  Simon Fraser University
  Designer: Rana Faryad Ali | E: ranaa@sfu.ca
  Professor: Bryon Gates | E: bgates@sfu.ca

- Tantalum oxide nanotubes grown on quartz for ultraviolet spectroscopy windows | Lab: Nanofab
  University of Alberta
  Designer: Ryan Kisslinger | E: kissling@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- The effects of shape, oligomerization and dimensionality on the electrical properties of tubulin polymers | Lab: Nanofab
  University of Alberta
  Designer: Aarat Kalra | E: aarat@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Tuning Heat dissipation at Interfaces | Lab: Toronto Nanofabrication Centre (TNFC)
  York University
  Designer: Shany Oommen | E: shanym@yorku.ca
  Professor: Simone Pisana | E: pisana@yorku.ca

- Vertical carbon nanotube-based photo-thermoelectric detector for room temperature human body thermal imaging | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Mingyu Zhang | E: m265zhan@uwaterloo.ca
  Professor: Tze-Wei (John) Yeow | E: jyeow@uwaterloo.ca

MNT: Photonics

- CMOS Compatible Bragg Reflection Waveguides for Second Harmonic Generation | Lab: Quantum NanoFab
  University of Toronto
  Designer: Trevor Stirling | E: trevor.stirling@mail.utoronto.ca
  Professor: Amr Helmy | E: a.helmy@utoronto.ca

- Enhancing Surface Nonlinear Optical Spectroscopy with Plasmonic Nanostructures | Lab: 4D LABS
  Simon Fraser University
  Designer: Anna Schiffer | E: aschiffe@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Fabrication and characterization of high efficiency and stable lead-free double perovskite solar cells | Lab: Nanofab
  University of Alberta
  Designer: Abdelrahman Askar | E: aaskar@ualberta.ca
  Professor: Karthik Shankar | E: kshankar@ualberta.ca

- Gas sensor using an array of multiplexed deformable Fabry-Perot interferometer with functionalized polymer | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Leandro Acquaroli | E: leandro.acquaroli@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- Gas sensor using an array of multiplexed deformable Fabry-Perot interferometer with functionalized polymer | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Régis Guertin | E: regis.guertin@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- High reflective coating on concave As2S3 fiber facet | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Kaixuan Zhang | E: kaixuan.zhang@mail.mcgill.ca
  Professor: Martin Rochette | E: martin.rochette@mcgill.ca

- Integration of pixelated GaN LEDs onto a flexible device | Lab: Quantum NanoFab
  University of Waterloo
  Designer: Mohsen Asad | E: m4asad@uwaterloo.ca
  Professor: Manoj Sachdev | E: msachdev@uwaterloo.ca

- Investigation of the two-photon photoluminescence efficiency of single crystalline and polycrystalline gold nano-antennas | Lab: 4D LABS
  Simon Fraser University
  Designer: Sasan V. Grayli | E: sasanv@sfu.ca
  Professor: Gary Leach | E: gleach@sfu.ca

- Nanophotonics for ultra-high sensing applications | Lab: NanoFab
  University of Alberta
  Designer: Dipanjan Nandi | E: dipanjan@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- On-chip delay line of coupled-resonator optical waveguides | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Marc-Antoine Bianki | E: marc-antoine.bianki@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- Optical modulation of nature inspired flexible pre-structured metallo-dielectric films | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Ali El-Hadi Zeineddine | E: ali.zeineddine@mail.utoronto.ca
  Professor: Nazir Kherani | E: kherani@ecf.utoronto.ca

- Optimisation of Fabry-Perot gas sensor microfabrication process | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Régis Guertin | E: regis.guertin@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- Organic thin-film transistors for pressure sensing application | Lab: Nanofab
  University of Alberta
  Designer: Michael Facchini-Rakovich | E: mf4@ualberta.ca
  Professor: Manisha Gupta | E: mgupta1@ualberta.ca

- Silver-dielectric plasmonic graded nanogratings for near-field light enhancement | Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Katelyn Dixon | E: katelyn.dixon@mail.utoronto.ca
  Professor: Nazir Kherani | E: kherani@ecf.utoronto.ca

- SU-8 whispering-gallery-mode microresonators for gas sensing applications | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Cédric Lemieux-Leduc | E: cedric.lemieux-leduc@polymtl.ca
  Professor: Yves-Alain Peter | E: yves-alain.peter@polymtl.ca

- Surface Enhanced Fluorescence Spectroscopy using Plasmonic Width-graded Nanogratings | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Moein Shayegannia | E: moein.shayegannia@mail.utoronto.ca
  Professor: Nazir Kherani | E: kherani@ecf.utoronto.ca

- System-level integration of active silicon photonic biosensors for blood test | Lab: Advanced Materials and Process Engineering Laboratory (AMPEL)
  University of British Columbia
  Designer: Enxia Luan | E: eluan@ece.ubc.ca
  Professor: Karen Cheung | E: kcheung@ece.ubc.ca

- Towards the first electrically pumped organic semiconductor lasers (OSL) | Lab: GCM Lab
  Polytechnique Montréal
  Designer: Mohammed Zia Ullah Khan | E: mohammed-zia-ullah.khan@polymtl.ca
  Professor: Stéphane Kéna-Cohen | E: s.kena-cohen@polymtl.ca

- Ultrathin Metal-Dielectric Nanogratings for Surface Enhanced Raman Spectroscopy | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Katelyn Dixon | E: katelyn.dixon@mail.utoronto.ca
  Professor: Nazir Kherani | E: kherani@ecf.utoronto.ca

MNT: Other Technologies

- Development of the of LabPETII scanners with DOI capabilities | Lab: 3IT
  Unversité de Sherbrooke
  Designer: Haithem Bouziri | E: haithem.bouziri@usherbrooke.ca
  Professor: Réjean Fontaine | E: rejean.fontaine@usherbrooke.ca

- Enhanced Raman Spectroscopy Using Facile NanoPlasmonic Devices | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer: Moein Shayegannia | E: moein.shayegannia@mail.utoronto.ca
  Professor: Nazir Kherani | E: kherani@ecf.utoronto.ca

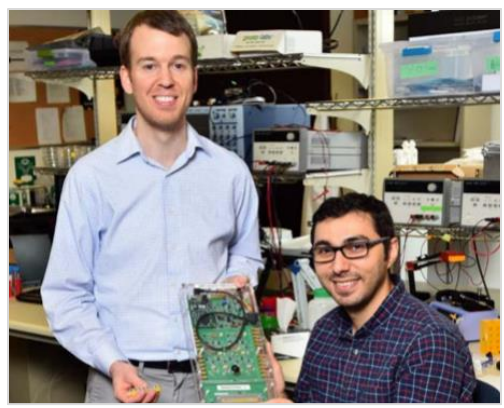
- PEODT:PSS/activated carbon composites based flexible organic electrochemical transistors | Lab: Toronto Nanofabrication Centre (TNFC)
  University of Toronto
  Designer Name(s): Zhihui Yi | E: zhihui.yi@utoronto.ca
  Professor: Mohini Sain | E: m.sain@utoronto.ca

Appendix A-1 – Success Stories in 2018/19

CMC is proud to support the innovative work of researchers in Canada. To read CMC Success Stories, including the examples listed below, see www.cmc.ca/SuccessStories

- Seeing modern agriculture in a new light
  Jayshri Sabarinathan
  Western University
  Professor Sabarinathan has used her experience with microsensors and nanofabrication to develop higher-performing multi-spectral cameras for agricultural monitoring in collaboration with industry partner A&L Canada Laboratories. Specifically, she has been increasing the wavelength bands captured by cameras, which in turn increases the type of data they can collect.
  (Published February 2019)

- A new approach to an old cure
  Micromensio | http://micromensio.com
  Founders: Brendan Crowley and Enver Kilinc
  Micromensio, worked with University of Toronto Professor Glenn Gulak, and collaborators Karen Maxwell and Will Navarre, to develop a low-cost, rapid sensing technology that targets bacterial infections. Unlike current diagnostic techniques, the company's disposable, wireless microchips can be placed directly into a bacterial sample and can tell within 15 minutes whether the phages successfully attacked the bacteria. The platform can also be tailored to other biosensing applications.
  (Published: December 2018)



Appendix A-2 – CNDN – by the numbers

2018/19:

A Canada-wide collaboration between **67** universities/colleges to connect **10,000** academic participants with **1000** companies to design, make and test micro-nanosystem prototypes. CMC Microsystems manages Canada's National Design Network® (CNDN).

2018 Outcomes:

3655 publications

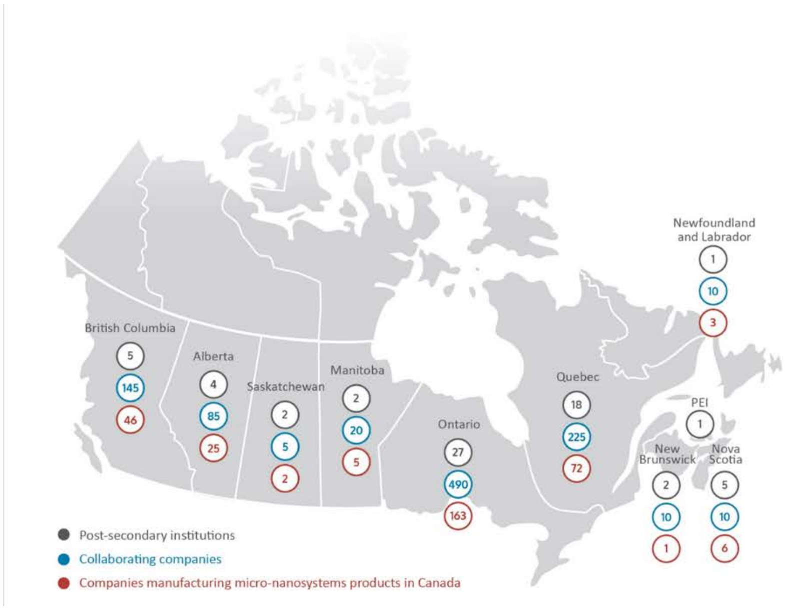
165 awards

85 patents awarded

555 collaborations

20 new startups

785 trained HQP moved to industry



Annually:

1260 connected professors

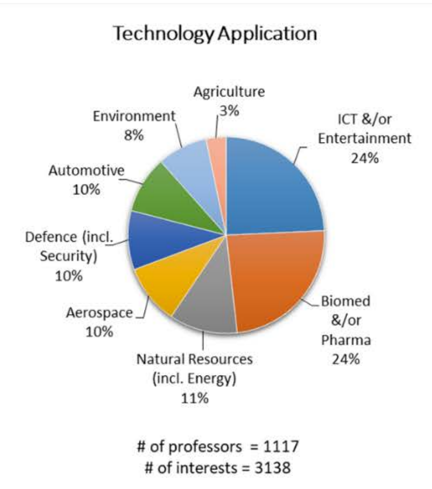
8850 researchers on professors' teams

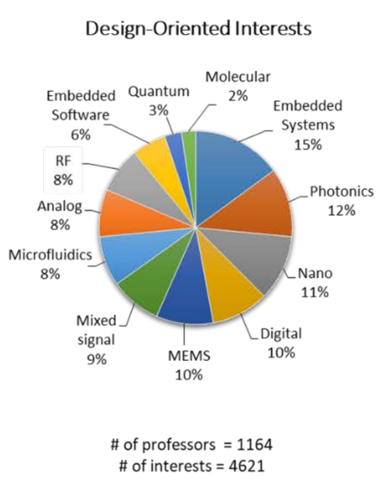
6200 users of computer aided design tools

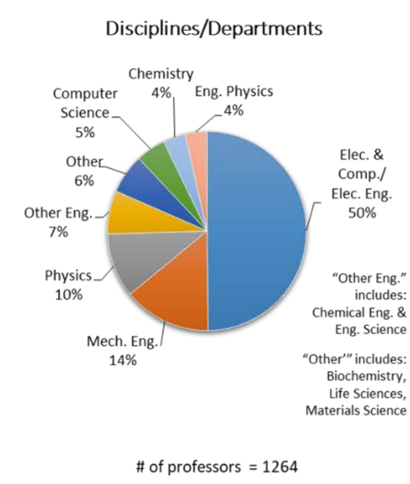
360 physical prototypes

80 equipment rental items otherwise unaffordable to users

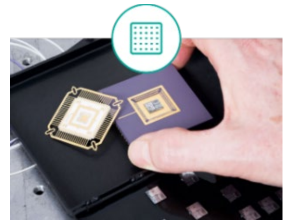
CNDN Academic Landscape 2018/19:







Appendix B – Fabrication Services for Prototypes



Microelectronics

STMicroelectronics FD SOI 28nm CMOS
TSMC 65nm GP CMOS
TSMC 65nm LP CMOS
TSMC 0.13µm CMOS
TSMC 0.18µm CMOS
TSMC 0.35µm CMOS
AMS 0.35µm CMOS - options: Standard, Opto, High Voltage, Post Processing
Teledyne DALSA 0.8µm CMOS - options: Standard Voltage, High Voltage

Photonics & Optoelectronics

AMF Silicon on Insulator, Passives and Actives
Epitaxy - options:
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

MEMS

MEMSCAP PiezoMUMPs
MEMSCAP PolyMUMPs
MEMSCAP - Post-processing for PolyMUMPS
Micralyne MicraGEM-Si™
Teledyne DALSA MIDIS™ Platform

Micro-Nano Technologies (MNT) Facilities Portal

40+ facilities located at universities across Canada

- Multi-project wafer services with affordable access to foundries worldwide
- Fabrication and travel assistance to prototype at a university-based lab
- Value-added packaging and assembly services
- In-house expertise for first-time-right prototypes

Don’t hesitate to contact me about opportunities for industry and academic R&D.

Gayathri Singh
Technical Team Leader, Microelectronics
+1.613.530.4690
Singh@cmc.ca

This represents a sample of the prototyping products available to Canada’s National Design Network.
More information:

www.cmc.ca/FAB

Appendix C – Industrial SponsorChip – New!

CMC Microsystems is pleased to offer the SponsorChip program for companies to enhance their research efforts and their links to academic researchers.

Choose a chip fabrication technology and topic areas of interest and CMC takes care of the rest.

What you Get

- Identify potential future partners, explore topics in the design and manufacturing space, submit your own designs alongside those of the students - stimulate the research community and contribute to grad student skill development in your area of interest - and benefit from CMC know-how
- **What professors get**: low cost access to silicon that allows you, your students, and your research staff to test out new ideas and to publish
- **What students get**: mentoring, knowledge gained in hot industrial topics, affordable chip fabrication, exposure to possible future employers

Sponsorship Examples

- **TSMC 65 nm CMOS Standard Process**: CAD $80,000 | 12 mm2 design area | Average 6-12 design submissions | Technical and logistical support from CMC
- **130 nm CMOS from TSMC:** Research area: low power electronics for IoT
- **65 nm CMOS from TSMC**: Research area: CMOS RF circuits
- **Silicon photonics with active components from AMF**
- **MIDIS inertial sensor process from Teledyne DALSA**

CMC provides

- A call for proposals to over **1,000 researchers** and their teams
- Full suite of **CAD software** to researchers undertaking the sponsored activity
- **Hands-on training and support** of from schematic to layout to package and test
- A timeline for design submission, fabrication, and test
- Reviews of the sponsored activity to ensure quality and return on investment
- Testing support through equipment loans and process debug

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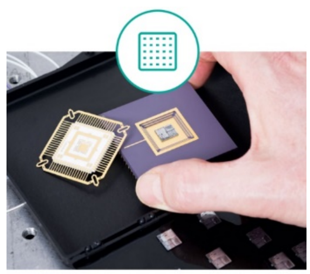

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