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## Towards an ultrafast all-fiber laser source for mid-infrared spectroscopy

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have been associated with improved glucose homeostasis, were increased in *Mgl1*<sup>-/-</sup> mice. This analysis opens up the prospect of identifying and characterizing commensal bacteria influenced by altered levels of mono-acylglycerols and the activity of their receptors, which possibly mediate the phenotype of *Mgl1*<sup>-/-</sup> mice and play a role in metabolism. Funding: We thank the Canada Excellence Research Chair on the Microbiome-Endocannabinoidome Axis in Metabolic Health (CERC-MEND), Université Laval.

### **THE ECOCHIP: A WIRELESS MULTI-SENSOR PLATFORM FOR COMPREHENSIVE ENVIRONMENTAL MONITORING**

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The EcoChip is being developed in the course of the Sentinel North sub-project 3.2 - Comprehensive environmental monitoring and valorisation: From molecules to microorganisms. Sentinel North's Technology maturation fund is now allowing our team to address some remaining technical challenges before we can undertake the next steps towards final validation and technology transfer to industry. The EcoChip has been jointly developed and validated in the laboratory by our multidisciplinary team, and utilized to collect bio-environmental data in the field from the northern soils and ecosystems of Kuujjuarapik (2017) and Puvirnituk (2018), during two expeditions. We are currently working toward the development of a precommercial version, thanks to the Technology maturation fund, and we

plan to release a prototype and test it in the field this summer. We believe the EcoChip will fill the gap in the field of bioremediation and global bio-environmental monitoring, which both may represent major markets. The technology has reached a development stage that justified recently filing a provisional patent application. We are now seeking industrial partners that could use this technology in commercial applications. The EcoChip is a new autonomous wireless sensor platform intended for culturing and monitoring the growth of microorganisms and their environmental conditions in situ, in harsh environments, such as in northern climates. This platform includes a layered multiwell plate that allows the growth of single strain microorganisms, within a well of the plate, isolated from environmental samples from northern habitats. It can be deployed in the field for continuous monitoring of microbial growth within 96 individual wells through a multichannel electro-chemical impedance (EIS) monitoring circuit. The EIS monitoring system uses high-performance off-the-shelf electronic components, presents low excitation voltage signal not to harm the cells and has a calibration network for high-precision. Additional sensors are provided for measuring environmental parameters such as luminosity, humidity, and temperature. The embedded electronic board is equipped with flash memory to store sensor data over long periods of time, as well as with a low-power micro-controller, and a power management unit to control and supply all electronic building blocks. When a receiver is located within the transmission range of the EcoChip, a low-power wireless transceiver allows transmission of sensor data stored in the flash memory. The performance of the system was successfully measured in vitro in a laboratory setting. The EcoChip can perform EIS analyses over an excitation frequency range of 750 Hz to 10 kHz with an accuracy of 2.35%. The complete system presents an average power consumption of 114.6 mW in normal operating mode and of only 0.14 mW in sleep mode.

### **TOWARDS AN ULTRAFAST ALL-FIBER LASER SOURCE FOR MID-INFRARED SPECTROSCOPY**

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Recently, there has been much interest in environmental monitoring to quantify and model the climatic changes affecting our planet. One of the objectives of the BOND project within Sentinel North is to develop mid-infrared lasers to detect and quantify atmospheric pollutants fluxes escaping from thermokarsts in the Arctic in real time. These devices could enable year-round real time flux measurements by replacing more expensive setups such as Eddy towers or devices such as closed or dynamic chambers that require more work force and that cannot stay in place year-round [1]. In the last few years, efficient supercontinuum emission in the transparency window of the atmosphere between  $3\ \mu\text{m}$  and  $5\ \mu\text{m}$  and efficient ultrafast laser emission tunable up to  $3.6\ \mu\text{m}$  have been generated from laser oscillators emitting ultrafast pulses near  $2.8\ \mu\text{m}$  [2, 3]. These kinds of laser sources are promising for probing the strong fundamental ro-vibrational resonances of multiple atmospheric pollutants at the same time such as  $\text{CH}_4$  and  $\text{CO}_2$  over long distances, but they must be robust and reliable if they are to be used in harsh environments such as Arctic regions. In this contribution, we study alternative designs using either a semiconductor saturable absorber mirror (SESAM) or a  $\text{Dy}^{3+}$ -doped silica fiber for generating ultrafast pulses with a linear laser cavity to design a robust ultrafast all-fiber laser operating near  $3\ \mu\text{m}$  to replace previous sources for broadband mid-infrared laser emission. The mode-locked  $\text{Er}^{3+}$ -doped fluoride fiber laser generates pulses as short as 15 ps with an average power of 58 mW at a repetition rate of 55 MHz using a SESAM (BATOP, GmbH) and is stabilized at 2791 nm by a fiber Bragg grating. By butt-coupling the SESAM directly to the fiber tip, an all-fiber design could be implemented to provide the robustness and reliability required for field applications. Alternatively, the use of a  $\text{Dy}^{3+}$ -doped silica fiber as saturable absorber to generate ultrafast pulses will be studied. The measured absorption spectrum of this fiber should provide enough saturable absorption, and its form factor makes it very durable. Moreover, numerical simulations show promising results with at least passive Q-switching occurring. Finally, the ultimate objective of this project is to generate a broadband laser emission tuned for methane spectroscopy by amplifying the shortest pulses generated by the ultrafast laser and integrate it into a remote sensing device to quantify the fluxes of methane. [1] M. Gålfalk, G. Olofsson, P. Crill, and D. Bastviken,

“Making methane visible,” *Nat. Clim. Chang.*, vol. 6, no. 4, pp. 426–430, Apr. 2016. [2] J.-C. Gauthier et al., “Mid-IR supercontinuum from 2.4 to  $5.4\ \mu\text{m}$  in a low-loss fluoroindate fiber,” *Opt. Lett.*, vol. 41, no. 8, p. 1756, Apr. 2016. [3] S. Duval et al., “Watt-level fiber-based femtosecond laser source tunable from 2.8 to  $3.6\ \mu\text{m}$ ,” *Opt. Lett.*, vol. 41, no. 22, 2016.

## **BIOPHILIC DEVELOPMENT OF ADAPTIVE FAÇADES FOR HEALTHY AND ENERGY-EFFICIENT BUILDINGS IN QUEBEC'S NORTHERN TERRITORIES**

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This research aims at developing biophilic adaptive façades as a promising solution to promote occupants' health and building energy efficiency in the extreme-cold climate of Quebec's northern territories. Adaptive façades point to the (self-) adjustment of façade components (such as shading panels, windows and blinds) to occupants' needs and environmental conditions in order to improve the overall performance of the building. Meanwhile, biophilic design offers several recommendations to promote human-nature relationships in buildings. The biophilic development of adaptive façades has considerable potentials to deal with the challenging state of living and working in northern latitudes. Strong seasonal light/dark cycles (photoperiods) come with very low average weather temperatures creating an extreme climate for living and working in northern latitudes. In such harsh climates, occupants spend most of their time inside buildings and their health is highly affected by the indoor environment. More specifically, accessibility to natural light and cycles affects occupants' health and behavior as well as energy consumption of buildings. In this regard,