~ RRM@UL ~

Réseau de recherche en microfluidique à l'Université Laval

En collaboration avec :

Sentinelle Nord
Regroupement stratégique en microsystème du Québec (ReSMIQ)
IEEE-Section Québec / Chapitre EMBS-CAS

Programme du :

Symposium annuel du réseau de recherche en microfluidique à l'Université Laval

Thème :
La microfluidique dans la recherche nordique

Salle: **VCH-3820**, le mardi **20 juin 2017** de **9h30 – 17h15**

Horaire

9:30-10:00 : Accueil et réseautage

10:00-11 :00 : Conférencier 1: Professeur Yves-Alain Peter (École Polytechnique de Montréal)

11:00-12:00 : Première session des présentations des étudiants, A. Miled

11:00 : *Micropompe biocompatible pour dispositifs à très faible pression pour la libération contrôlée des médicaments*, **Hamza Landari**

11:15 : *Système de récupération de bio-énergie à partir de bactéries pour l'exploration sous-marine*, **Hajer Abed**

11:30 : *Perfusable 3D microfluidic channels: in pursuit of a cure for type 1 diabetes*, **Gabrielle Gauvin-Rossignol**

12:00-13:00 : Repas et réseautage

13:00 -14:00 : Conférencier 2: Professeur Jean-Michel Lemieux (Univ. Laval)

14:00-14:30 : Implication du réseau de recherche en microfluidique à l'Université Laval à SN

- Professeur Greener: Thème 3.1 Sentinel microbiomes, genes and molecules for Arctic ecosystem health: "Using microfluidics to study photosynthetic biofilm mats"
- Professeur Miled: Thème 1.4 Photonic sensing and monitoring of permafrost environments for sustainable development of the north: "autonomous power systems using microbial fuel cells"
- Professor André Bégin-Drolet: Thème 3.4 Enabling tools for the monitoring of food quality in the Northern environment: "A portable microfluidic-based food quality tool"

14:30- 15:30 : Deuxième session des présentations des étudiants, J. Greener

14:30 : *Linear scan infrared spectroscopy applied to* Pseudomonas sp. *biofilms growing inside microchannels*, **M. Pousti,**

14:45 : *Pattern formation of non-Newtonian fluid flows in Hele Shaw cell*, **A. Eslami**

15:00 : *pH sensitive chitiosan membrane for sequence release of mesoporous silica particles sequence release*, **Jia Nan,**

15:15 : *Hydrodynamic Effects on Biofilms at the Bio interface Using a Microfluidic Electrochemical Cell*, **Mirpouyan Zarabadi**

15:30-15:45 : Pause café et réseautage

15:45-16:45 : Conférencier 3: Professeur Jose Moran-Mirabal (Univ. McMaster)

16:45-17:15 : Cérémonie de remise de prix, réseautage et clôture du symposium.

Conférencier : Yves-Alain Peter

Resonant optical lab-on-a-chip

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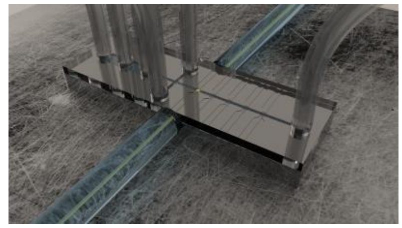
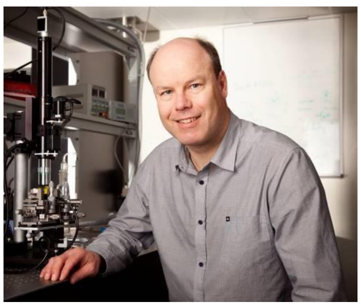


On chip optical microresonators [1, 2] are compact, robust and can be integrated with micro electro-mechanical components as well as microfluidics. They can efficiently sense acceleration [3], forces [4], gases [5], refractive index of liquids [6] and living cells [7, 8], and bacteria [9].
During the presentation I will give an overview of projects exploiting this new avenue (sensors and tunable devices based on different types of optical microresonators). In-plane Fabry-Pérot microcavities integrated on chip will be specifically highlighted through several different applications.

Biography



Yves-Alain Peter received the M.Sc. degree in physics and the Dr.Sc. degree from the University of Neuchâtel, Switzerland, in 1994 and 2001, respectively. In 1995, he joined the Department of Medical Radiobiology as a Research Associate at the Paul Scherrer Institute, Switzerland. From 1995 to 2001, he was a Graduate Research Assistant with the Applied Optics Group, Institute of Microtechnology, University of Neuchâtel. From 2001 to 2003, he was a Post-Doctoral Researcher with the Microphotonics Group, Stanford University. From 2003 to 2004, he was a Research and Development Engineer and a Project Leader with the Swiss Center for Electronics and Microtechnology, Switzerland. In 2004, he joined Polytechnique Montréal, Canada, where he is now Professor of Engineering Physics. His current research interests include microphotonics and micro-opto-electro- mechanical systems.

References

[1] R. St-Gelais, A. Poulin, and Y.-A. Peter, IEEE/OSA Journal of Lightwave Technology 30, 1900 (2012)
[2] S. Bergeron, S. Saïdi, and Y.-A. Peter, Optics Express 18, 16797 (2010).
[3] K. Zandi, J.A. Bélanger, and Y.-A. Peter, IEEE Journal of Microelectromechanical Systems 21, 1464 (2012)
[4] A. Poulin, R. St-Gelais, A. L. Eichenberger, L. Thévenaz, and Y.-A. Peter, IEEE Journal of Microelectromechanical Systems 22, 884 (2013)
[5] R. St-Gelais, G. Mackey, J. Saunders, J. Zhou, A. Leblanc-Hotte, A. Poulin, J. A. Barnes, H.-P. Loock, R. S. Brown, and Y.-A. Peter, Sensors & Actuators B: Chemical 182, 45 (2013)
[6] R. St-Gelais, J. Masson, and Y.-A. Peter, Applied Physics Letters 94, 243905 (2009)
[7] A. Leblanc-Hotte, J.-S. Delisle, S. Lesage, and Y.-A. Peter, Solid-State Sensors, Actuators and Microsystems Workshop, Hilton Head, 327 (2014)
[8] A. Leblanc-Hotte, J.-S. Delisle, S. Lesage, and Y.-A. Peter, IEEE International Conference on Optical MEMS and Nanophotonics, Singapore, 167 (2016)
[9] H. Ghali, H. Chibli, P. Bianucci, J. L. Nadeau, and Y.-A. Peter, Biosensors 6, 20 (2016)

Conférencier : Jean-Michel Lemieux

Suivi de la dynamique d'écoulement des eaux souterraines en régions froides

Professeur agrégé, département de géologie et de génie géologique, Université Laval
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Field investigations have recently been conducted near Umiujaq (Nunavik, Canada), an inuit community located on the eastern shore of Hudson Bay (Quebec), in order to assess the present and future availability of groundwater for sustainable use and drinking water management in northern communities. The field work combined detailed hydrologic, hydrogeologic, geophysical and thermal investigation methods in a small 2 km2 watershed located in a large valley east of Umiujaq, which drains into the northern end of Lac Guillaume-Delisle. This site is located in the discontinuous permafrost zone where significant permafrost degradation has been observed over the last two decades. The watershed is characterized by the presence of a thick coarse-grained glaciofluvial deposit forming a good aquifer sitting beneath a thick silty marine unit containing discontinuous ice-rich permafrost. Another shallow surficial aquifer exists above the silty unit.
An extensive monitoring network has been recently installed in the watershed, including 3 weather station, 24 groundwater monitoring wells, 9 drive points, 100 soil moisture and temperature probes in the unsaturated zone, 40 surface temperature probes, 3 snowpack thickness measurement stations, 4 heat flux plates and a H-flume at the outlet of the watershed. 12 thermistance arrays installed in permafrost and non-permafrost areas have also been installed prior to and during this research. Sampling of groundwater in the wells and surface water in small lakes and at the catchment outlet was carried out for geochemical analysis (inorganic parameters, stable isotopes of oxygen and hydrogen and radioactive isotope of carbon, tritium and helium) and assessment of the water quality and origin.
In this presentation, the monitoring network will be introduced and an outlook of the hydrogeology of the watershed will be given based on the preliminary interpretation of the newly acquired data from the network.

Jean-Michel Lemieux est professeur agrégé au Département de géologie et de génie géologique de l'Université Laval depuis 2009 et Éditeur de la revue Hydrogeology Journal, le journal officiel de l'Association internationale des hydrogéologues. Il a obtenu un baccalauréat en génie géologique (2000) et une maîtrise en sciences de la Terre (2002) de l'Université Laval, ainsi qu'un doctorat en sciences de la Terre de l'Université de Waterloo (2007). Par la suite, il a travaillé comme hydrogéologue chez SNC-Lavalin à Montréal (2006-2007), a complété un stage postdoctoral à l'Université de Liège en Belgique (2007-2008) et a été chercheur à l'ETH-Zurich, en Suisse (2008-2009). Il s'intéresse à l'observation et à la modélisation numérique des processus hydrogéologiques passés, présents et futurs. Depuis 2011, il mène des travaux de recherche en hydrogéologie au Nunavik.

Conférencier : Jose Moran-Mirabal

Microfluidic devices with integrated structured electrodes for on-chip sensing

Associate Professor, Department of Chemistry and Chemical Biology, McMaster University, Hamilton, Ontario, Canada

The development of widely applicable point-of-care sensing and diagnostic devices can benefit from simple and inexpensive fabrication techniques that expedite the design, testing, and implementation of lab-on-a-chip devices. In particular, electrodes integrated within microfluidic devices enable the use of electrochemical techniques for the label-free detection of relevant analytes. This work presents a novel, simple, and cost-effective bench-top approach for the integration of high surface area three-dimensional structured electrodes fabricated on polystyrene (PS) within poly(dimethylsiloxane) (PDMS)-based microfluidics. The fabrication and bonding processes are shown to have no effect on sensing electrode performance. Two configurations of three-electrode electrochemical cell are tested, and a salt bridge-free configuration is used for sensing. Finally, the on-chip sensing capabilities of the electrochemical cell are demonstrated with a model redox compound, where the high surface area structured electrodes exhibit ultra-high sensitivity. We propose that the developed approach can significantly expedite and reduce the cost of fabrication of sensing devices where arrays of functionalized electrodes can be used for point-of-care analysis and diagnostics.

Bio: Jose Moran-Mirabal is an Associate Professor in the Department of Chemistry and Chemical Biology at McMaster University. Jose's research combines the strengths of micro- and nanofabrication, biomolecular patterning, and high-resolution fluorescence microscopy to study targeted bio-molecular interactions in vitro. Current research projects in his laboratory include the development of bench-top approaches to produce micro- and nanostructured surfaces for applications in on-chip sensing, biocomposite characterization, and cell microenvironment engineering, the development of novel surface chemistry approaches to functionalize cellulose, and the development of micropatterning approaches to produce complex surface patterns of lipids and cells to study cell-lipid and cell-cell interactions.
Jose obtained a BSc. in Engineering Physics and MSc. in Biotechnology from ITESM, in Monterrey, Mexico. He then joined the group of Prof. Harold Craighead at Cornell University, where he performed research on the application of micro and nanofabricated surfaces for the study of lipid membranes. He received his PhD. in Applied Physics from Cornell University in 2007. From 2007 to 2011, he worked as Post-Doctoral and Research Associate in the Biofuels Research Laboratory at Cornell University under the supervision of Prof. Larry Walker. There, he applied quantitative fluorescence methods to the study of cellulase binding kinetics, binding reversibility, and catalysis. Jose joined the Department of Chemistry and Chemical Biology at McMaster University in July 2011, and is the recipient of an Early Researcher Award from the Province of Ontario.

Présentations des étudiants

1. Micropompe biocompatible pour dispositifs à très faible pression pour la libération contrôlée des médicaments

Hamza Landari, Marc-André Dussault, Jean Ruel, Andre Begin-Drolet, Amine Miled

Département de génie électrique et génie informatique, Faculté des sciences et de génie, Université Laval

Nous présentons, à travers ce travail, une nouvelle architecture de micropompe miniaturisée pour la libération de médicaments dédiée aux applications biomédicales à basse pression et aux dispositifs implantables. Après modélisation du système par la MEF, deux techniques de fabrication de la membrane ont été utilisées. Les dimensions de la micro-chambre de pompage étaient de 1 mm x 1 mm x 0,8 mm.

2. Système de récupération de bio-énergie à partir de bactéries pour l'exploration sous-marine

Hajer Abed, Mehran Abbaszadeh-Amirdehi,, Jesse Greener, Amine Miled

Département de génie électrique et génie informatique, Faculté des sciences et de génie, Université Laval

Cette présentation est une introduction à nos récents travaux portant sur la récupération d'énergie à partir de bactérie dans un système contrôlé. On présentera le concept utilisé, l'architecture proposée ainsi que quelques résultats expérimentaux et préliminaires.

3. Perfusable 3D microfluidic channels: in pursuit of a cure for type 1 diabetes

Gabrielle Gauvin-Rossignol, Jean Ruel, Stephanie Fernandez, Richard Leask, Corinne Hoesli, André Bégin-Drolet

Département de génie mécanique, Faculté des sciences et de génie, Université Laval

In a context where type 1 diabetes affects more than 2 000 000 people in Canada alone, the search for a long-term treatment for this disease is imperative. Type 1 diabetes is an immune system malfunction causing the loss of insulin-producing beta cells. Insulin is a crucial hormone for the regulation of blood glucose concentration. The absence, or lack, of beta cells results in high blood glucose level, a potentially deadly situation. The most common current therapy is exogenous insulin administration. Islet transplantation has emerged as an alternative treatment that can avoid the need for insulin injections in ~40% of patients for at least 3 years. However, to avoid graft rejection, recipients are placed under immune suppression, which leads to unwanted side effects. No cure has been found so far. The ultimate and ambitious goal of our project is to develop a cure by restoring insulin secretion to each patient. As a solution, our research team has proposed a bioartificial pancreas were new encapsulated stem-cell derived beta cells would provide the insulin needed to survive. However, these cells need sufficient oxygenation to survive and overcome hypoxia, which can be achieved through proper vascularization of the artificial organ. The proposed methodology to obtain perfusable 3D microfluidic channels within the artificial organ relies on additive manufacturing of sugar glass. First, a 3D printed sugar glass mold is created and cell-laden alginate is casted around the construction. The sugar is then dissolved, leaving a gel with hollow channels needed for proper cell oxygenation and nutriment supply. This presentation presents the advancement made so far and the challenges to come.

4. **Linear scan infrared spectroscopy applied to *Pseudomonas sp.* biofilms growing inside microchannels**

M. Pousti, *J. Greener*

Département de chimie, Faculté des sciences et de génie, Université Laval

The fact that we can investigate the distribution of different chemicals in flows without tracers or dyes makes IR spectroscopy a powerful tool in microfluidic devices. Attenuated total reflectance infrared (ATR-IR) spectroscopy is well suited for strongly absorbing hydrated samples, such as bacterial biofilms because IR beam penetration depth into the sample is less than 2 um. However, it is not naturally suited for spatially-resolved measurements. Here we present an *in situ* linear scanning mode for ATR-IR inside microchannels. Measurements to growing biofilms are presented.

5. **Pattern formation of non-Newtonian fluid flows in Hele Shaw cell**

A. Eslami, *S.M. Taghavi*

Department of Chemical Engineering, Laval University

This work aims to experimentally study the Saman-Taylor instability of air invasion into a non-Newtonian fluid (i.e., Carbopol solution) in a rectangular Hele-Shaw cell. The non-Newtonian fluid used exhibits a yield stress, shearthinning and elastic eects. Three main flow regimes were observed based on different morphologies of the finger patterns, including ramified structure, narrow single-finger and side-branching patterns. We analyze the flow regimes from various perspectives. There are a number of important dimensionless numbers that largely describe the flow regimes: the Bingham number (Bn), the capillary (Ca), theWeissenberg number (Wi), the channel aspect ratio (δ) and the shear-thinning power-law index (n). We are able to combine the dimensionless numbers to form new groups that bring important insights to the problem.

6. **pH sensitive chitiosan membrane for sequence release of mesoporous silica particles sequence release**

Jia Nan, *Erica Rosella, Estelle Juère, Freddy Kleitz, Jesse Greener*

Department of Chemistry and Centre de recherche sur les matériaux avancés (CERMA), Université Laval

Here we demonstrate a way to biofabricate a thickness controllable chitosan membrane in microdevice. By applying different synthesis conditions, we form bi-layer chitosan membrane and embed different fluorescence labeled mesoporous silica particles in each layer. The approach has the potential to add smart drug delivery functionality to membranes for special applications in organs on a chip and other areas of regenerative medicine.

7. Hydrodynamic Effects on Biofilms at the Bio interface Using a Microfluidic Electrochemical Cell

Mirpouyan Zarabadi and Jesse Greener

Département de chimie, Faculté des sciences et de génie, Université Laval,

Study of bio interface is essential for understanding behavior of biomaterials such as biofilms in different surfaces. We believe that the anchoring biofilm layer is expected to exhibit a different response to environmental stresses than for portions in the bulk, due to the protection from other strata and the proximity to the attachment surface. Our new microfluidic electrochemical flow cell provides an opportunity for a fundamental study of biofilm dynamic in flow and hydrodynamic effects on biofilm-substrate interface that have never been done before. In addition, this new electrochemical device allows us to monitor biofilm growth and real-time measurement of electrochemical responses.

Reference:

Zarabadi, M. P., Paquet-Mercier, F., Charette, S. J., & Greener, J. (2017). Hydrodynamic Effects on Biofilms at the Biointerface Using a Microfluidic Electrochemical Cell: Case Study of *Pseudomonas sp*. *Langmuir*, 33(8), 2041-2049.