MSc Project in Electrical Engineering

Beginning: May 2018 or September 2018

Interdisciplinary Institute for Technological Innovation (3IT)
Department of Electrical and Computer Engineering
Université de Sherbrooke, Québec, Canada

Laboratory: **Quantum Semiconductors and Photon-based BioNanotechnology**
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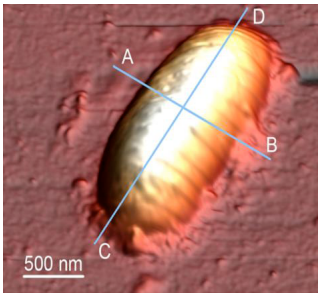
Subject: *In situ* Monitored Interaction Between Electrically Charged Molecules and Functionalized Surfaces of III-V Quantum Semiconductors

Project summary

The Quantum Semiconductors and Photon-based BioNanotechology Laboratory of the **Interdisciplinary Institute for Technological Innovation** (3IT) has been involved in the fundamental and applied research of the interactions between electrically charged molecules and functionalized surfaces of III-V quantum semiconductors (QS). One of the axes of this activity is focused on the development of a QS biosensor for rapid detection of viruses and bacteria. Our interest in this research is driven by the urgent need of developing devices attractive for rapid monitoring of environment (e.g. recreational water) and food industry products for the presence of health compromising pathogens.



AFM picture of *E. coli* immobilized specifically on the biofunctionalized surface of GaAs (001) [Duplan et al., Sensors & Actuators **B160**, 46-51 (2011)].

If a negatively charged biomolecule (viruses and bacteria are negatively charged objects) is immobilized in the vicinity of a semiconductor surface (~10 nm), it could affect band bending of such a semiconductor. This, in addition to the charge transfer, could modify optical properties (e.g., photoluminescence) of the semiconductor. We have measured this effect with a high precision in our laboratory. Of particular interest is that bacterial metabolism leads to the emission of H^+ ions, which could modify the process of bacteria-semiconductor interaction. This is what we hope to demonstrate in the frame of this project (**Goal 1**).

With our QS photonic biosensing approach (QSPB), we have already achieved rapid detection of *E. coli* and *L. pneumophila* bacteria.[1-2] We have also demonstrated that bacterial reaction to antibiotics could be monitored with this technique.[3] The detection sensitivity of the QSPB technique depends on the controlled photocorrosion of GaAs/AlGaAs nano-heterostructures.[4] A the threshold conditions of the photocorrosion, we expect to have maximum sensitivity, which will be targeted by this research (**Goal 2**).

Required skills

We are looking for a physics or electrical engineering student with background in solid state and semiconductor physics. The candidate should be highly motivated, enjoy hands-on work, and demonstrate independent thinking leading a project to conclusion. The candidate should be interested to work in an interdisciplinary environment of physics, chemistry and microbiology researchers.

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1. Nazemi, E.; Aithal, S.; Hassen, W. M.; Frost, E. H.; Dubowski, J. J., GaAs/AlGaAs heterostructure based photonic biosensor for rapid detection of Escherichia coli in phosphate buffered saline solution. *Sensor Actuat B-Chem* **2015,** *207*, 556-562.
2. Aziziyan, M. R.; Hassen, W. M.; Morris, D.; Frost, E. H.; Dubowski, J. J., Photonic biosensor based on photocorrosion of GaAs/AlGaAs quantum heterostructures for detection of Legionella pneumophila. *Biointerphases* **2016,** *11* (1), 019301.
3. Nazemi, E.; Hassen, W. M.; Frost, E. H.; Dubowski, J. J., Monitoring growth and antibiotic susceptibility of Escherichia coli with photoluminescence of GaAs/AlGaAs quantum well microstructures. *Biosens Bioelectron* **2017,** *93*, 234-240.
4. Dubowski, J. J.; Nazemi, E.; Aithal, S.; Huang, X., Photo-electrochemical sensing method using photoluminescence-emitting semiconductors. *Patent* **2015,** *PCT/CA2015/050073 (Allowed, to be issued in Summer 2018)*.