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Research opportunity for **MSc** and **PhD** students in  
physics, materials engineering, bio-physics and nanomedicine

**Laboratory for Quantum Semiconductors and Laser-based Nanotechnology**  
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## Quantum Semiconductor Device for Rapid Detection and Typing of Human Influenza Infections

### Summary

Currently available viral diagnostics methods are slow, expensive and restricted to a single virus or family. Ideally, it would be useful to identify rapidly and simultaneously a broad spectrum of viruses. The proposed approach aims at developing a cost-effective quantum semiconductor device for the rapid detection and typing of human influenza infections. The device consists of arrays of epitaxial quantum dots (eQD's), which previously have been known for their applications in advanced communication systems such as quantum dot lasers.

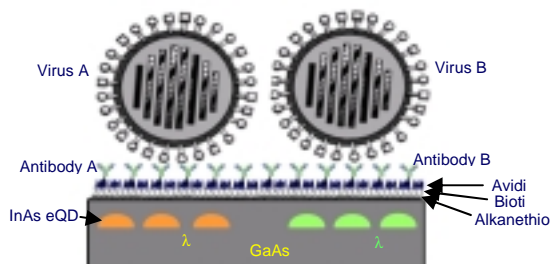
### Background

Semiconductor colloidal quantum dots (cQD), such as CdSe, CdTe, InAs, InP, and other nano-size particles such as gold, silver, gold coated iron, or iron oxide, which are capable of interfacing with biological systems, have recently attracted widespread interest in biology and medicine. They are thought to have potential as novel luminescent and detection enhancing probes for *in-vivo* diagnostics (e.g., imaging), therapy (e.g., drug development and delivery) and sensing applications. In spite of the impressive progress in this area in the recent 5-7 years, the technology of cQD's remains relatively immature. One of the severe limitations in the application of cQD's for biosensing is their intermittent photoluminescence, known as the 'blinking' effect. Also, the influence of different dyes bound to protein linkers on biosensor performance is the subject of intense investigations that, due to the colloidal nature of the sensing environment, limit the range of technologies available to assist the development of the biosensor to those based on wet chemistry. Consequently, commercially available cQD's are relatively expensive.

To overcome some of the key technological problems and limitations related to the application of cQD's for biodetection, we have proposed a device based on arrays of epitaxial QDs (eQD) that have been grown directly on different substrates by thin film deposition technology.

### Epitaxial quantum dots (eQD's) – an innovative approach for biodiagnostics

The idea of the eQD biosensor is summarized in Figure. 1. A wafer with eQD's emitting at a specific wavelength, or with rows of eQD's emitting at  $\lambda_1, \lambda_2, \lambda_3$ , etc., is functionalized with biotinylated antibodies of different analytes. Upon excitation, each eQD, which typically is 20 - 40 nm in diameter at its base, will emit photoluminescence (PL) radiation in a rapidly expanding cone. This radiation is expected to



**Figure 1.** A schematic architecture of the proposed biosensor. Detection of the eQD photoluminescence is used to monitor the surface state of the biosensor (Dubowski, Ding, Frost and Escher, patent pending).

be modified in the presence of nano-objects, such as trapped viruses, located 2 - 8 nm above the biofunctionalized surface of eQD. Thus, the measurements of the PL signal originating from eQD will provide a convenient way to rapidly monitor the changes taking place at the surface of the sensor. Other effects, such as surface plasmon resonance have also been investigated to evaluate the detection potential of the proposed biosensor.

The choice of InAs eQDs emitting at near 1.1-1.2  $\mu\text{m}$ , which coincides with the wavelength at which live tissue exhibits minimum optical attenuation, has been dictated by our long-term interest in exploring the feasibility of this approach for *in-vivo* bio-diagnostics.

### **Enabling technology**

The eQD's do not suffer from the blinking effect, thus they are potentially attractive for single biomolecule detection. An atomically clean surface, selective area functionalization, tuning the emission wavelength of an individual eQD or groups of eQD's and implementation of *in-situ* diagnostics will be enabled by laser-based materials processing technologies that we have been developing at CEGI. This approach will make it possible to fabricate eQD templates with the unique optical characteristics required to fulfill the need of the optimized performance of a specific bio-sensor microstructure.

### **Prototype device and verification of the idea**

To provide conditions for direct trapping of the influenza A virus, we have been investigating a thiol-biotin-avidin-biotinylated antibody architecture. However, other interfaces, in particular those involving DNA biomoieties are also in the field of our interest.

### **Team and Partners**

Development of this biosensor is carried out in collaboration with researchers from the Faculty of Engineering (CEGI) and Faculty of Medicine CHUS (Department of Microbiology and Infectious Diseases Department of Pharmacology). Clinical tests of the device are scheduled to begin at CHUS in 2007. The activity is currently supported by CIHR and the Canada Research Chair in Quantum Semiconductors program.

### **R&D Program – Opportunity for students and young researchers**

This program offers the opportunity for young researchers and students to join our multidisciplinary team of physicists, chemists, materials engineers, a microbiologist, a pharmacologist and a clinician, and to participate in the quest for development of this innovative biosensor. The broad platform technology developed in the frame of this program is expected to make possible the rapid detection of a variety of human pathogens. Suitable research candidates (MSc and PhD levels) are invited to contact: [jan.j.dubowski@usherbrooke.ca](mailto:jan.j.dubowski@usherbrooke.ca).