Engineering and Innovation Research Studentship 2023/2024

Project title:	**Development of wearable nanobiosensors for health and space applications**
Discipline	Bioengineering / Bionanotechnology / Biosensors
Key words:	biosensor, immunosensor, microfluidics, nanotechnology, fluorescence, bioelectronics/bioengineering, 3D-printing.
Supervisory team:	Dr Sotiria Psoma, Dr Luisa Pedro
URL for lead supervisor's OU profile	https://www.open.ac.uk/research/people/sp26342

Project Highlights:

- Identification of important biomarkers for humans' health and wellbeing in relevant biofluids (sweat, tears, saliva, blood, interstitial fluid); and stable and robust bioreceptors.
- Development of low-cost, easy-to-miniaturise and energy efficient transducers suitable for wearable devices.
- Development of microfluidic and optofluidic platforms for successful sampling from the liquids of choice and biosensors integration.
- Development of technologies and solutions for integration of bioreceptors/nanomaterials with biosensors resulting in robust and long-lasting devices.

Overview:

In the last few decades, we are experiencing a revolution in genetic analysis, as DNA diagnostics have brought large changes in many scientific areas, including the mapping of the human genome. Biosensors are at the forefront of this tremendous revolution as they are small, simple, cost-effective and perform at very high standards. Particularly in combination with nanomaterials, such as quantum dots, graphene and molecular imprinted polymers, are promising and exciting technologies that will allow a faster, cheaper and simpler way to obtain sequence-information compared to traditional hybridisation assays and will allow us to detect DNA damage and interactions. In the last decade, we have also witnessed the successful commercialisation of several wearable devices, which mainly sense physiological parameters (Figure 1). These wearable biosensors with access either to sweat or to bloodstream and/or interstitial fluids could provide information about not only the pulse rate but also stress levels, hydration, kidney function, the presence of cancer cells, blood pressure and blood sugar, predicting and potentially preventing heart attacks as well as other cardiovascular diseases and other important medical conditions[1]. Such devices would be in high demand in several sectors including precision medicine[2] and aerospace to monitor closely the astronauts' wellbeing and health during long-duration space travel[3]. Wearable biosensors can contribute significantly to achieving sustainable healthcare systems and more specifically facilitating prevention, early detection, and minimal invasive management of diseases[4].

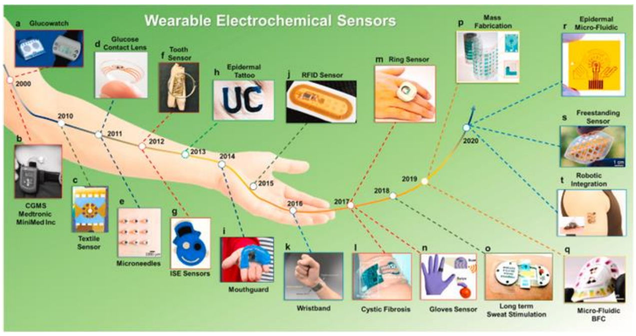

Figure 1. Evolution timeline of wearable electrochemical sensors in North America[5].

Methodology:

The project aim is to explore and further develop different technological methods for portable or implantable biomedical devices such as wearable nanobiosensors for health and space applications. The research is qualitative and quantitative and will involve both development of theoretical and analytical tools, the design of certain instrumentation, the investigation of chemical reactions using enzymes and DNA sequences such as aptamers, development of microfluidic chambers and experimental assessment configurations. This combination provides a useful foundation for an in depth understanding of the chemical and physical processes involved and the development of the wearable biosensors using electrochemical and optical detection techniques.

The research will involve an early literature review to establish a good background knowledge of this inter-disciplinary field. The review may focus on existing conventional technologies for wearable biosensors, their advantages and disadvantages in combination with the specific requirements of health and space applications. Emphasis will be given to the exploitation of microtechnology and nanotechnology for the development of wearable nanobiosensors. Challenges and opportunities identified in the literature will be used to refine the detailed planning of the project and the methodology.

Theoretical simulations (using a Multiphysics commercial software such as COMSOL) will be carried out in order to model processes that are necessary for the microfluidic platform of the biosensor. In addition, simulations will be used for investigating chemical reactions that take place using electrochemistry or surface plasma resonance (SPR) in order to optimise the parameters and can be exploited in nanobiosensors. For example, if a specific enzyme or an aptamer will be used to detect targeted biomarkers from biofluidics, then electrochemistry will be used to provide voltammetric data from the chemical reactions. Also, a three-dimensional geometrical model of the microfluidic chamber will be developed, and a finite element analysis will be carried out in order to define the anticipated forces that can be used to calculate the anticipated detection levels of the biomarker [6,7]. These simulations will be used to perform experiments using analytical chemistry instrumentation such as potentiostat or microplate reader (absorbance/ fluorescence) to study the specific chemical reactions or immunoassays.
The practical design of selected biosensor configurations will be carried out with the aim to be utilised in health and space applications. This involves the selection of the appropriate transducers, the design of the electronics, the design of the experiment for the performance assessment, the data analysis and the requirements for special conditions. Micro- and nano- manufacturing processes will be utilized for the development of multiple wearable biosensors.

Due to the interdisciplinary nature of the project, at each stage of the PhD, the candidate will be given the opportunity to follow appropriate training sessions. In addition, he/she will be encouraged to present and publish the results of his/her work as this enhances the verification process of the research via peer and external review and also facilitates the development of academic skills.

References & Further reading:

1. Possanzini, L., Decataldo, F., Mariani, F., *et al*., (2020) Scientific Reports, 10, 17180.
2. Teymourian H., Parrilla M., Sempionatto J.R., *et al*., (2020), ACS Sensors, 5, 2679-2700.
3. Roda A. , Mirasolia M., Guardiglia M., *et al*., (2018), Biosensors and Bioelectronics, 111, 18-26.
4. Kim J., Campbell A.S., Esteban-Fernández de Ávila B., Wang J., (2019) Nature Biotechnology, 37, 389-406.
5. Ray T.R., Choi J., Bandodkar A.J., *et al*., (2019) Chemical Reviews, Chemical Reviews, 119, 5461-5533.
6. Sobianin I., Psoma S.D. and Tourlidakis A., (2022), Energies, 15, Article 7959(21).
7. Psoma S.D., Sobianin I. and Tourlidakis A., (2022), Engineering Proceedings, 16(1) (pp. 1-14).

Further details:

The candidates should have a good honours degree in a STEM subject and a good background in bioengineering or/and bioelectronics or/and bionanotechnology or a related subject. Knowledge of 3D printing techniques or/and analytical chemistry techniques such as electrochemistry and biosensor technology are desirable but not essential. The student will join a well-established team of biosensor technology and bioelectronic engineering researchers at the Open University.

Please contact **Dr Sotiria Psoma**
Sotiria.Psoma@open.ac.uk for further information.

Applications should include:

- A 1000-word cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- an Open University application form, downloadable from: http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process
- IELTS test scores where English is an additional language

Applications should be sent to
STEM-EI-PhD@open.ac.uk by 15.02.2023