Digital microfluidics for biosensing

Proposers

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Introduction

Lab-on-chip biosensing devices have gathered much attention as they have the promise of achieving point-of-care, inexpensive, easy-to-use quantification of relevant biomarkers for human or animal health, food processing and food safety, and environmental applications and biopharmaceuticals development. One key challenge in microfluidic devices is to increase the sensitivity of the microfluidic assays, towards fM and better. Sensitivities at these levels would open new applications in the early detection of health biomarkers and are also key in environmental applications. Digital microfluidics, in which the sample of interest is divided in a large number (up to 10^6) of fractions and each fraction is addressed for the presence of the analyte, has the potential to yield several orders of magnitude of increase in assay sensitivity. Nevertheless, important challenges still need to be overcome in the fluidic handling, sensing, signal acquisition in terms of sensitivity and speed and in signal processing before the potential of digital microfluidics can be used in realistic applications.

Partner 1

The Thin-Film MEMS and BioMEMS group at INESC MN (www.inesc-mn.pt) has extensive experience developing and PDMS-based microfluidics for biosensing, cell-chips, and separation of bioproducts. Particular recent focus has been on integrated sample preparation modules, optical detection, and the use of nanoporous microbeads. The participating laboratory will be responsible for the development of the digital microfluidic platforms.

Partner 2

iMed, is the research Institute of Medicines at Faculdade de Farmacia aa Universidade de Lisboa with a mission to develop innovative medicines and benefit human health through top class multidisciplinary research, technology and innovation. The area of drug discovery focuses on integrating cell-based approaches with emerging high-throughput systems aiming the discovery of new biopharmaceutical drugs. The participating laboratory will supply test systems for the digital microfluidic platforms.

Project outline/goal

In this project, we propose to develop a digital microfluidic system for biosensing. This system will include the fluidic handling, a (optical) sensor and the electronics required for signal acquisition and processing. In addition, the signal processing required for the analysis of the results will also be developed. Two technical approaches will be explored: a droplet microfluidic approach and an arraying approach. In the droplet microfluidic approach, the sample solution is divided in a series of nL-pL droplets that flow sequentially in a channel, separated by mineral oil. In the arraying approach, the sample solution is divided in a static 2D array of nL-pL spots using microwells. The individual fractions of the solution will be interrogated optically for the presence of the target. While in the droplet approach a single sensor can be used, but the speed of signal acquisition is key since the droplets are in motion at high speeds in the microfluidic channel, in the arraying approach the main challenge is to interrogate each individual microwell that sits in a distinct spatial location. The data in both approaches is generated in high volumes at high speeds and its processing needs also to be addressed. The digital microfluidic devices will be first characterized and modelled with a set of model solutions and then be tested in real-world conditions: (i) detection of microorganisms; (ii) detection of antibody biomarkers; (iii) single-cell approaches for biopharmaceutical drug discovery.

Student profile

Profile sought: preference, but not limited, to students with a background in Biomedical Engineering or Biological Engineering with an interest in Physics, Devices, and Electronics. Also appropriate to students with a background in Physics with an interest in Electronics or Electrical Engineers with an interest in exploring complex microfluidic systems for biotechnological applications. Experience in Micro and Nanofabrication would be helpful.