Digital Microfluidic Lab-on-a-chip for multiplex detection of biomarkers in Exhaled Breath Condensate

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Background

- Exhaled breath (EB) carries diagnostic biomarkers, which are biological indicators of infection and disease.
- Microfluidics is the science of miniscule volumes of fluid, its manipulation and the study of its behaviour
- Digital Microfluidics (DMF) technology involves the manipulation of an ultra-small droplet on an array of microelectrodes
- A lab-on-a-chip (LOC) device combines laboratory tests, such as blood analysis, ELISA assays and DNA amplification, all on a single miniature chip.
- Digital microfluidic multiplex LOC detection of lung disease biomarkers from EB can be carried out noninvasively and painlessly at point-of-care by the use of EB collection devices.

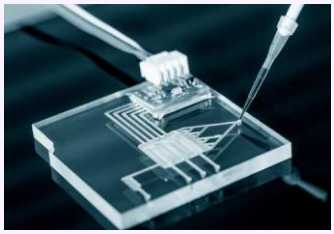

Figure 1: A digital microfluidic system (Berthier, 2018). Figure 2: A multiplex lab-on-a-chip device (Maxwell, 2016).

Motivation

- Asthma UK states that 'lung diseases are responsible for more than 700,000 hospital admissions and over 6 million inpatient bed-days in the UK each year' and that 'somebody dies from lung disease in the UK every 5 minutes' (British Lung Foundation, 2017).
- Current diagnostic tests require thorough lab work that is carried out in laboratories by skilled laboratory professionals one biomarker at a time, when this could be fully automated at point-of-care, eliminating wasted time and money
- 'It is thought that approximately 10% of the population have a needle phobia' (NHS Foundation Trust University Hospital Southampton, 2018). Therefore more non-invasive testing and diagnostic devices are necessary.

Objectives

The desired outcome of this project is to create a multiplex lab-on-a-chip device that can detect respiratory biomarkers, making lung disease detection and diagnosis fast, cost effective, non-invasive, portable and useable at point-of-care. This is expected to be achieved by:

- Identifying biomarkers from EB
- Creating immunoseparation assays for biomarkers
- Using 3D printing to create a multiplex DMF LOC device

Methodology

1. Research and select respiratory biomarkers
2. Develop bio-printed immunoseparation sites for selected biomarkers using artificial EB and finalise assays
3. Analyse geometry and surface to volume ration to create LOC prototype using 2D and 3D printing
4. Combine immunoseparartion assays to create a multiplex chip
5. Test chip with healthy volunteer EB and analyse results

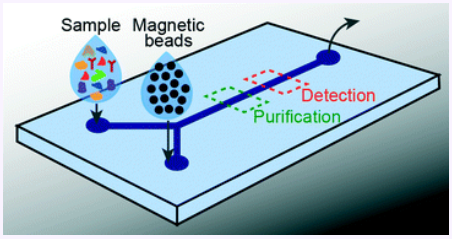

Figure 3: A basic figure to show immunoseparation on a chip (Tekin and Gijs, 2013)

Figure 4: EB collection device (Respiratory Research Inc., 2019)

Challenges

Challenges include:

- Researching and narrowing down the large sum of lung related biomarkers found in EB.
- Cost and availability of optimally compatible bio-inks.
- Cost of trial and error of 3D printing.

References

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