Delivering Bio-MEMS & MicroFluidic Education around Accessible Technologies

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Abstract:

Electronic Systems are now being deployed in almost all aspects of daily life as opposed to being confined to consumer electronics, computing, communication and control applications as was the case in the 90's. One of the more significant growth areas is medical instrumentation, health care, bio-chemical analysis and environmental monitoring. Most of these applications will in the future require the integration of fluidics and biology within complex electronic systems. We are now seeing technologies emerging together with access services such as the FP6 "INTEGRAMplus" and "MicroBuilder" programs that offer competitive solutions for companies wishing to design and prototype microfluidic systems. For successful deployment of these systems, a new breed of electronic engineers are needed that understand how to deliver bio-chemistry and living cells to transducers and integrate the required technologies reliably into robust systems. This paper will report on initial training initiatives now active under the INTEGRAM*plus program.*

1 Introduction

INTEGRAM*plus*[1] is an Integrated Project funded by the European Commission and builds on the Europractice Manufacturing Cluster INTEGRAM, which focused on silicon sensors and electronics, extending the competencies to multi-technologies (silicon, polymers,..) and multi-domains (fluidic, optical, mechanical, electrical, biological). The project provides a one-stop shop including consultancy, training, design services, prototyping, packaging and manufacture. The consortium is led by QinetiQ and includes CSEM, Epigem and IMM for prototyping and low volume supply, Epigem and Silex for volume supply, Coventor on virtual prototyping (CAD) with support from three leading institutes, IMT, ITE, University of Lancaster, and market expertise from Yole Développement. The project has developed modular platforms for functional feasibility studies of bio, acoustic, optical, magnetic, inertial sensors based on polymer and silicon building blocks. These consist of standard components, e.g. microfluidic channels, optical waveguides, active components such as mixers, valves, accelerometers, transducers, ASICs, etc. which have standard interfaces for interconnection and allow 3D stacking. Access will be via design rules/guidance in handbooks and a high degree of customisation is possible, e.g. functionalisation of surfaces for specific customer bio-sensing applications.

To maximise uptake of this technology and deliver real benefits to society in terms of devices and systems, a cohort of Electronic Systems specialists are needed who understand the process of integrating multiple technologies such as silicon and polymer together with multi-energy domain functions. This does not suggest that engineers working in this field will require two university degrees but will require that engineers responsible for integrating technologies will understand the core principles and language used by bio-chemists, computational fluid dynamicists and photonics specialists in addition to the polymer based manufacturing industry. The demand for this type of training is backed up by survey carried out by the UK Institute for Nanotechnology[4]

A start has been made by the INTEGRAMplus project by developing a new module that aims to deliver the knowledge necessary to enable electronic engineers to understand how to achieve successful delivery of bio-chemistry and living cells to embedded sensor sites and gain an understanding and awareness of how to integrate fluidics, transducer technology and electronics into robust systems. The course is being developed at Lancaster University and being deployed within EC funded Continuing Professional Development courses such as "STIMESI"[2] and masters courses being run at Lancaster that include Bio-photonics and Micro & Nano Systems.

2 Course Format & Lecture Content

The course consists of a mix of lectures and practical training as shown in Fig. 1. The module on the basics of microfluidics includes introductory material on

μFluidic System Design Modules	Outputs
➢ Fluidics (Basics)	
➢ Technology platforms	
➢ Design process, simulation, modelling :	On-site and on-line lectures On-site or transportable practical exercise 0.5 – 1 day
➢ Integration Technologies	
➢ Practical (based on EPIGEM platform – possibly work of Hong)	

Fig. 1 : The format of the μFluidic System Design Course

mixing, valves, pumps and covers the core engineering science associated with flow behaviour (eg. Reynolds number), surface tension, diffusion, turbular and laminar flow and multi-phase systems. The introduction also introduces the concepts of electrowetting, electroosmotic flow and dielectropherisis as transport mechanisms for delivery systems including droplet or "digital" microfluidic systems.

The technology platform section summarises current fabrication technology including the solutions available through the INTEGRAMplus project. This includes the classical solutions in PDMS, various technologies for sealing through to silicon based systems including for example the QinetiQ based Hollow Wave Guide Technology. Simulation and modelling covers the EDA support that currently exists including CFD, FEA and Behavioural Modelling solutions including bespoke, dedicated tools such as those offered by Coventor. Integration technologies covers various methods of integrating silicon with polymer based packaging and delivery systems together with appropriate packaging technologies.

3 Practical

The practical is designed to build on the lecture material and provide students with a feel for using a microfluidic system to deliver a known assay or cellular sample to a transducer based system. The fluidic system is based around a set of μFluidic chips sourced from EPIGEM. The students explore the impact of flow rate on the effectiveness of mixing and separation in various structures including T and H channel systems (Fig. 1 & 2). They will also explore methods of

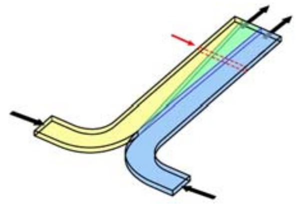

Fig. 2 : T-Channel passive mixing based on diffusion. If chaotic advection included, it will help to generate flow deformation hence improve the mixing efficiency.

cell sorting and separation using magnetic beads to simulate living cells using florescence based techniques. A case study will accompany this practical based on a

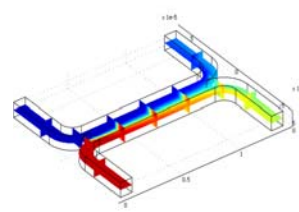

Fig. 3 : H-Channel passive separation through diffusion

demonstrator bio-platform that includes a microfluidics control system.

4 Dissemination

Maximising impact requires flexibility to adapt to a range of backgrounds and delivery styles. To assist this, the course will be build into the wider training portfolio available through the Network of Excellence in Micro & Nano Manufacture[3]. This portfolio will be captured within a web-based system over the second half of 2008 and will provide training providers across Europe access to the information required to engage with the lecturers concerned and access the material. It is expected that the entire course will be physically transportable and hence enabling a significant contribution to be made to courses at partner organisations.

5 References

1) Integrated MNT Platforms & Services INTEGRAM*plus* – Contract No 027540
2) "STIMESI" Stimulation action on MEMS and SiP (http://www.stimesi.org/home.html)
3) "Patent-DfMM" Network of Excellence in Design for Micro & Nano Manufacture (www.patent-dfmm.org)
4) Nanotechnology Skills and Training Survey, Institute of Nanotechnology, July 2007.