The promise of a microfluidic research network in South Africa – Establishment of the base within the CSIR

K LAND, M MBANJWA, S POTGIETER
CSIR Materials Science and Manufacturing, PO Box 395, Pretoria, 0001
Email: kland@csir.co.za – www.csir.co.za

INTRODUCTION

The science and engineering of systems and devices for manipulation of fluid, in the nano- and picolitre ranges, is called microfluidics. Microfluidic technologies have diverse applications ranging from micro fuel cells, to disease detection, to chemical and pharmaceutical production. This technology requires a range of multidisciplinary skills, which solicits skills and knowledge sharing between organisations to ensure competitiveness. While research activities in this field are still minimal in South Africa, the CSIR draws on its various competences and collaborates with partners locally and internationally. The CSIR has started focusing on capacity building in microfluidics research.

MICROFLUIDICS – AN OVERVIEW

Microfluidics is an emerging research area with most of its research undertaken in the past 20 years. The first major commercial application was the inkjet printer. Microfluidics in life sciences is an emerging market and holds great promise for the areas of medicine, biotechnology, ecology and drug discovery (Ducree & Zengerle, 2004).

A microfluidic system consists of a series of channels together with components such as pumps, valves, reservoirs and actuators to control the flow of fluids. These are integrated into a single unit to form what is known as a 'lab-on-chip' device. Lab-on-chip devices are used for performing physical, chemical, or biological functions, such as separation, mixing, chemical reaction and analysis (Liu *et al*. 2008; Nguyen & Wereley, 2006). These functions would normally be undertaken in a full-scale laboratory. Applications such as DNA separation, polymerase chain reaction, immunoassays, cell counting and cell culturing have been implemented on lab-on-chip devices (Sia & Whitesides, 2003).

Advantages offered by microfluidics include reduced sample and reagent use, reduction in waste products, reduced costs per analysis, faster response times, low energy requirements and improved process efficiencies (Nguyen & Wereley, 2006).

Early devices were manufactured using silicon-based methods, which are widely used in the micro-electromechanical (MEMS) and electronics industries. Polymer-based materials are currently preferred for microfabrication of devices due to lower cost compared to silicon, glass and quartz. A set of techniques, called soft lithography, has been developed where a master, or mould, is used to create replicas of the desired channel structure. The capital investment for implementing soft lithography is lower than for MEMS or electronics-based procedures, which makes it a good starting point for microfluidics, especially for developing countries.

It is believed that microfluidics will solve integration problems in biology and chemistry in the same way that the integrated circuit did for the microelectronic industry.

MICROFLUIDICS AT THE CSIR

A micromanufacturing Lab (Figure 1) was launched at the CSIR in 2007. The research activities in this facility have been focussed on developing expertise and capacity in microfluidics. Various research areas in the CSIR have discussed activities in microfluidics including laser-based machining, different applications (life sciences, energy, safety, security, defence, process production) and modelling and simulation.

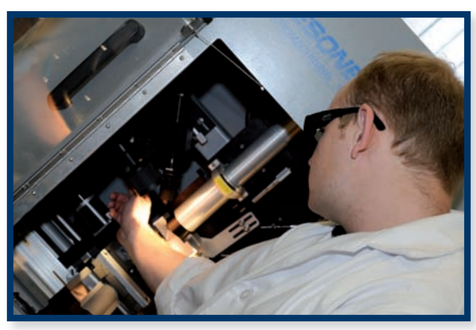

Figure 1

The know-how and capability of microfabrication methods are fundamental and essential to undertake sound microfluidic research. Design of laser-based machining methods, assembly of devices and implementation of control strategies are the key areas in which competency is being developed at the CSIR. Figure 2 shows a microchannel moulded from a polymer and measured with a confocal laser scanning microscope.

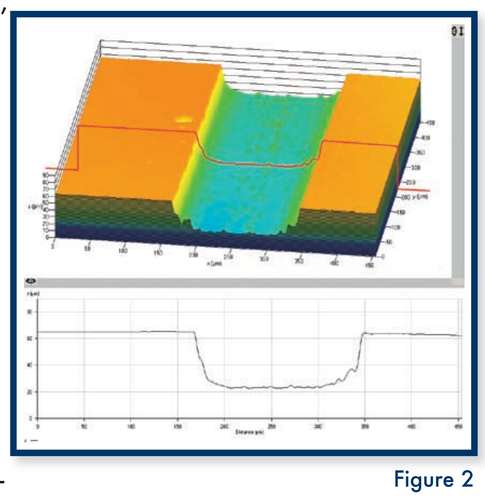

Figure 2

Soft-lithography is used for fabrication of microchannels. This technology offers a means for producing elastomer-based, low cost devices which are used in advanced microfluidic research. Establishment of a full soft-lithography facility is currently being investigated.

Modelling and simulation efforts have been focussed on fundamental studies of single phase and multiphase flows in microchannels using a computational fluid dynamics (CFD) package. Commercial computer programs are used on high performance desktop computers to achieve this end. Figure 3 shows some of the results from CFD modelling of microdroplet formation in microchannels.

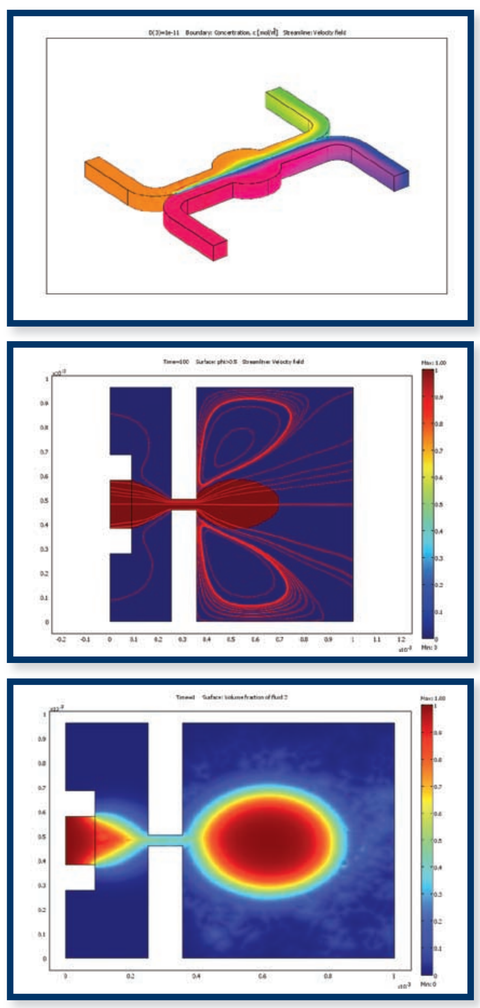

Figure 3

The CSIR has over the past two years established international research ties with the Institute for Microsystems Technology (IMTEK) at the University of Freiburg in Germany. IMTEK is a major international player in the area of micromanufacturing and microfluidics research. A memorandum of understanding will enable exchange of personnel for training and knowledge transfer.

TOWARDS A HEALTHIER SOUTH AFRICA

The lab-on-chip has huge potential to improve the quality of life in developing countries (Chin *et al*, 2006).

In personal health, communicable diseases (such as HIV/Aids, tuberculosis, malaria and hepatitis) and non-communicable diseases (such as cancer and diabetes mellitus) require early diagnosis to increase chances of successful treatment. However, access to healthcare facilities is still a problem for communities living in remote areas. This results in patients taking longer to get to hospitals or clinics for diagnosis. In many cases the diagnosis is made too late. Microfluidic devices will present a low cost, point-of-care solution for these diseases.

In the area of environmental health, water pollution is still one of the causes of diarrhoeal diseases such as cholera. Due to a lack of infrastructure for potable water, communities consume water from rivers, streams and other water sources without knowing the cleanliness of the water. Microfluidics devices will present a means of quick analysis before consumption and minimise the risk of people consuming polluted water.

CONCLUSION

- Microfluidics is an emerging research area internationally in which South Africa should participate
- A basic microfluidic manufacturing facility, the first in the country, has been established at the CSIR
- Investigations are ongoing to set up an advanced facility
- The CSIR is playing a pivotal role in creating a microfluidic research network.

REFERENCES

1. Chin, C. D., Linder, V. & Sia, S. K. Lab-on-chip devices for global health: Past studies and future opportunities. Lab on a chip, 7, pp 41-57, 2006.
2. Ducree, J. & Zengerle, R. (Eds). FlowMap- Microfluidics Roadmap for the life sciences. Demand GmbH, Norderstedt. 2004. ISBN: 3-8334-0744-1
3. Liu, L., Cao, W., Wu, J., Wen, W., Chang, D.C. & Sheng, P. Design and integration of an all-in-one biomicrofluidic chip. Biomicrofluidics, 2, pp. 034103-1 - 034103-8, 2008.
4. Nguyen, N. & Wereley, S.T. Fundamentals and applications of microfluidics. 2nd Ed, Boston: Artech House, 2006.
5. Sia, S.K. & Whitesides, G.M. "Microfluidic devices fabricated in poly (dimethylsiloxane) for biological studies", Electrophoresis, 24, pp 3563 – 3576, 2003.

The CSIR is developing a new technology, broadly referred to as microfluidics, which deals with the behavior, precise control and manipulation of fluids – with applications in areas such as micro fuel cells, disease detection, chemical and pharmaceutical production.