James Watt Institute *for* High Value Manufacturing

CO_2 laser based rapid prototyping of autonomous microfluidic systems

Dr Mazher-Iqbal Mohammed and Professor Marc P.Y. Desmulliez
Microsystems Engineering Centre (MISEC), School of EPS

HERIOT WATT UNIVERSITY

Introduction

The field of microfluidics and lab-on-a-chip technology is a highly emerging field of micro engineering, holding the potential to revolutionise processing capabilities across a range of high impact research areas, including medical diagnostics, environmental monitoring, forensics and chemical engineering. Despite the promise of such technology, microfluidics and lab-on-a-chip devices lack commercial acceptance, which can be attributed to the complexity and long turnaround time of device manufacturing or the necessity to initiate, control and manipulate the flow of fluidic on-chip by means of bulky assisting devices. Microfluidic devices are typically manufactured using photolithography and processes borrowed from the microelectronic industry. Limitations to this fabrication method include the need for skilled manpower, use of clean room facilities and high associated running costs. Laser etching/ablation based micro fabrication techniques suffer none of these hindrances and allow for reasonable quality microfluidic features to be manufactured within minutes and at a fraction of the cost.

CO_2 Laser Manufacturing

Laser based fabrication techniques are a highly emerging and promising technology that allows for the rapid and reproducible manufacturing of various microfluidic devices. The primary advantages of CO_2 laser manufacturing compared to standard techniques are:

- Compatibility with a wide range of substrates
- Rapid turnaround time ~ 2-3 minutes/chip
- Agile mask-less and clean room free technology
- Reproducible feature sizes ~ 100-150µm

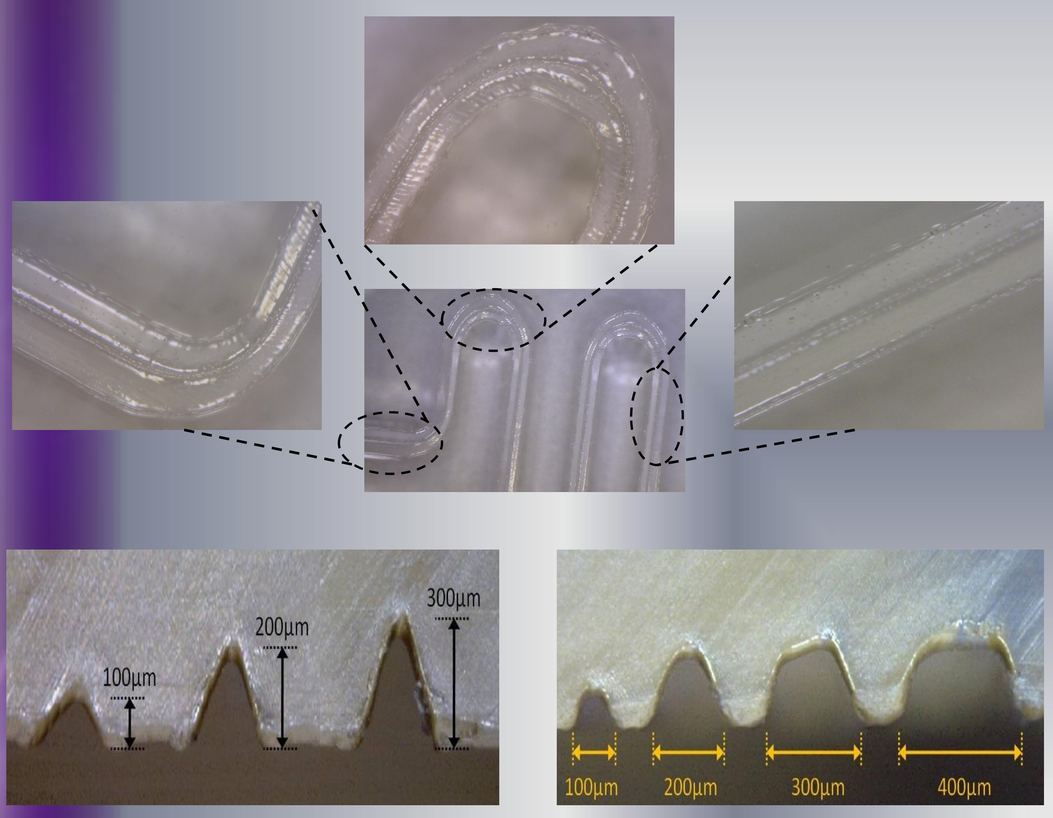

Figure 1: Various examples of CO_2 laser etched PMMA substrates

Autonomous Micro Pumping Systems

An elegant solution to on-chip fluidic actuation is the use of capillary forces to initiate and control fluidic flow as such pumping structures have zero power consumption and can be fabricated on-chip using standard manufacturing procedures, without significantly increasing the overall footprint of the microfluidic device. CO_2 laser etching has been utilised to create various pumping components within PMMA polymer substrates. Such devices have been applied towards the creation of various medical and environmental diagnostics platforms.

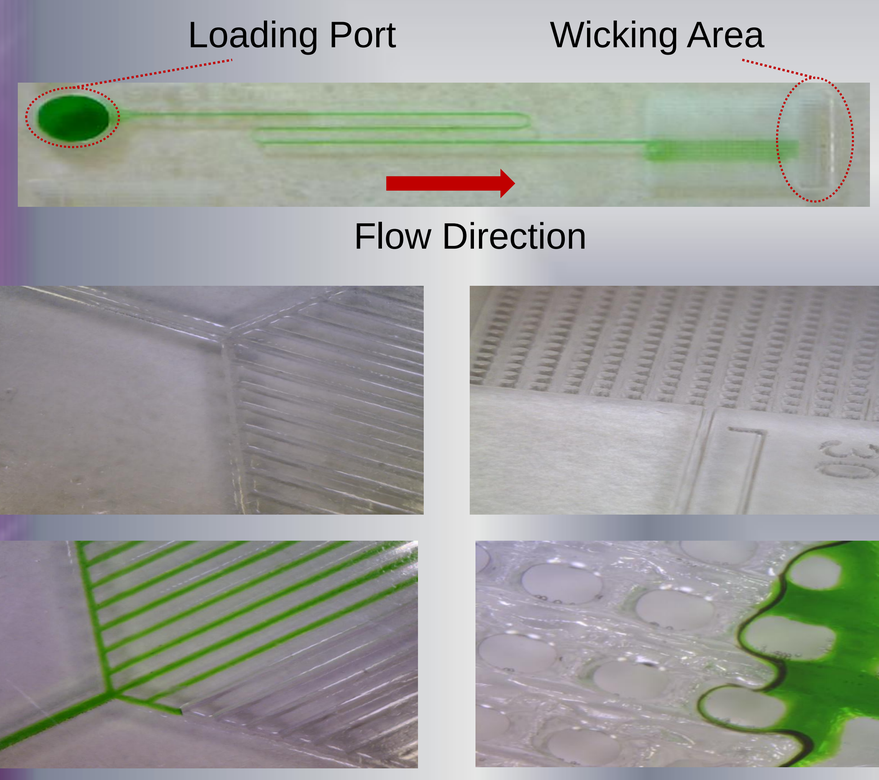

Figure 2: Various examples of CO_2 laser etched capillary micro pumps

Capillary Micro Valves

For angular geometrical changes to a micro channel it is found that pressure barriers can be established from the resulting surface tension affects at the boundary of the interface between a filled and non-filled channel. Valve structures utilising this phenomena have been created within PMMA using CO_2 laser etching, with functionalities ranging from stop, trigger and delay valves.

Figure 3: Examples of various stop valves

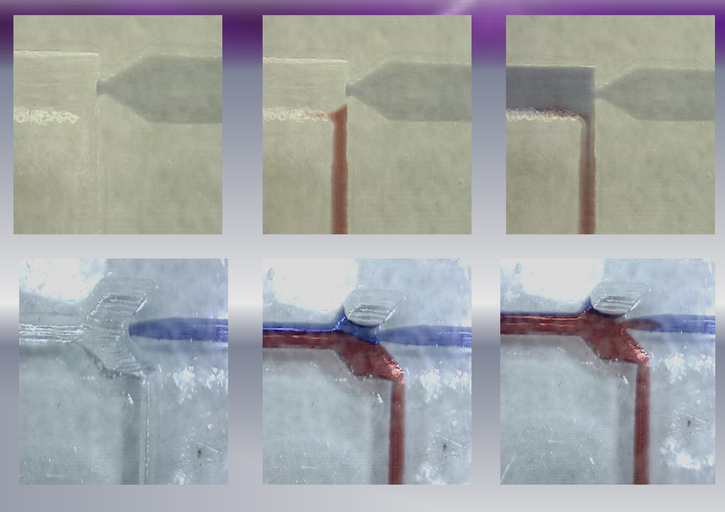

Figure 4: Examples of various trigger valves