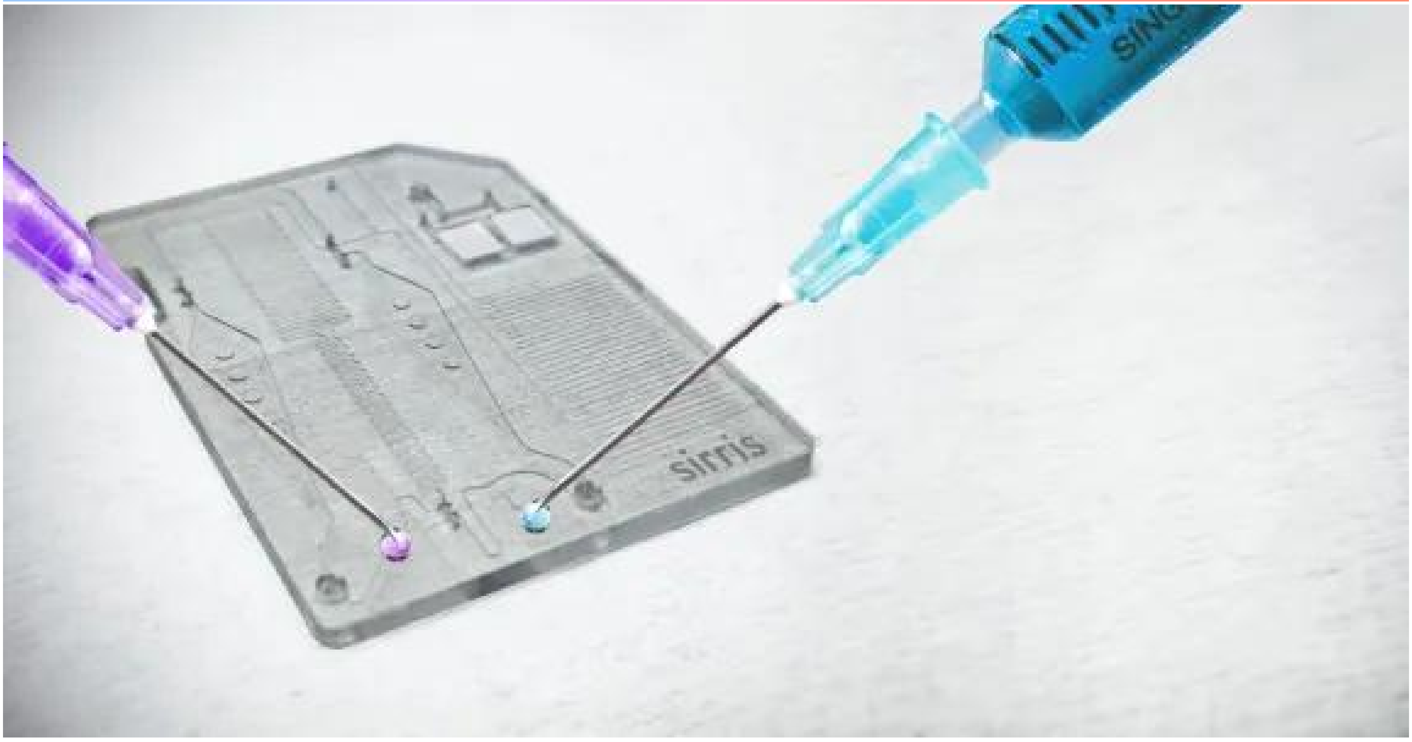

Manufacturing and prototyping techniques for polymer-based microfluidic chips: a brief overview | Part 3

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Microfluidics in industry

Polymer-based microfluidic chip production is ideally suited for high-volume, low-cost applications such as bedside diagnostics, quality control in the field and rapid sample preparation for analysis. A range of different techniques are used that make it possible to produce microscopic patterns on macroscopic parts, which is a characteristic of microfluidics. Some techniques are mostly used in research and development (R&D), while others are perfectly suited for industrial-scale production.

1) Soft lithography

Soft lithography in combination with casting a thermochemically-curing polydimethylsiloxane (PDMS) elastomer is a particularly well-proven technique in academic R&D. This allows the creation of flexible replicas that can be used either as parts or as moulds for reproducing microscale patterns in liquid materials as these are curing. This method adds great flexibility to the rapid prototyping of complex designs.

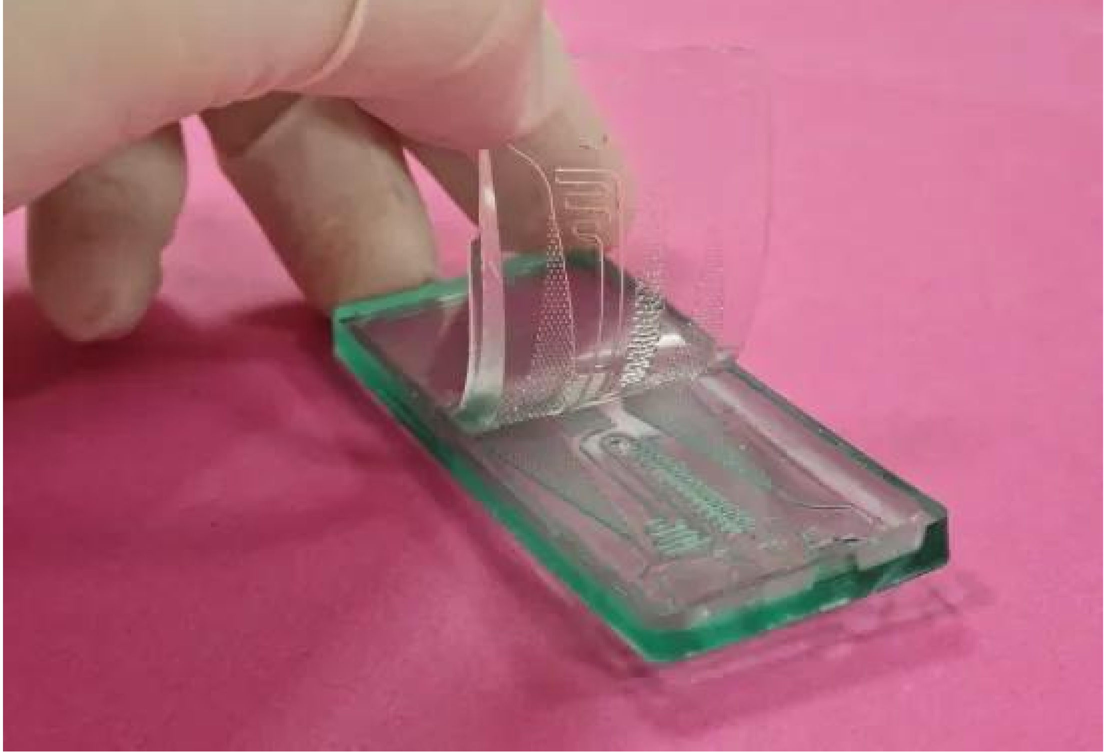

Figure 1: A PDMS replica obtained from a micro-3D printed master

2) Stacking and laminating pre-cut polymer films

Stacking and laminating pre-cut polymer films (by laser, milling or robotic cutting) is also a fast and simple prototyping technique that can be used in R&D to produce thin and/or flexible microfluidic systems.

3) 3D printing

3D printing - and, more specifically, micro-stereolithography and multiphoton polymerisation techniques - have recently proven particularly versatile in the production of microfluidic systems. They offer exceptional flexibility and enable the rapid creation of complex 3D structures via selective exposure of a photopolymer resin in successive layers. Although the technique is mainly used in R&D, it can also be used for the industrial production of small series and even the production of one-off pieces with a very high degree of customisation.

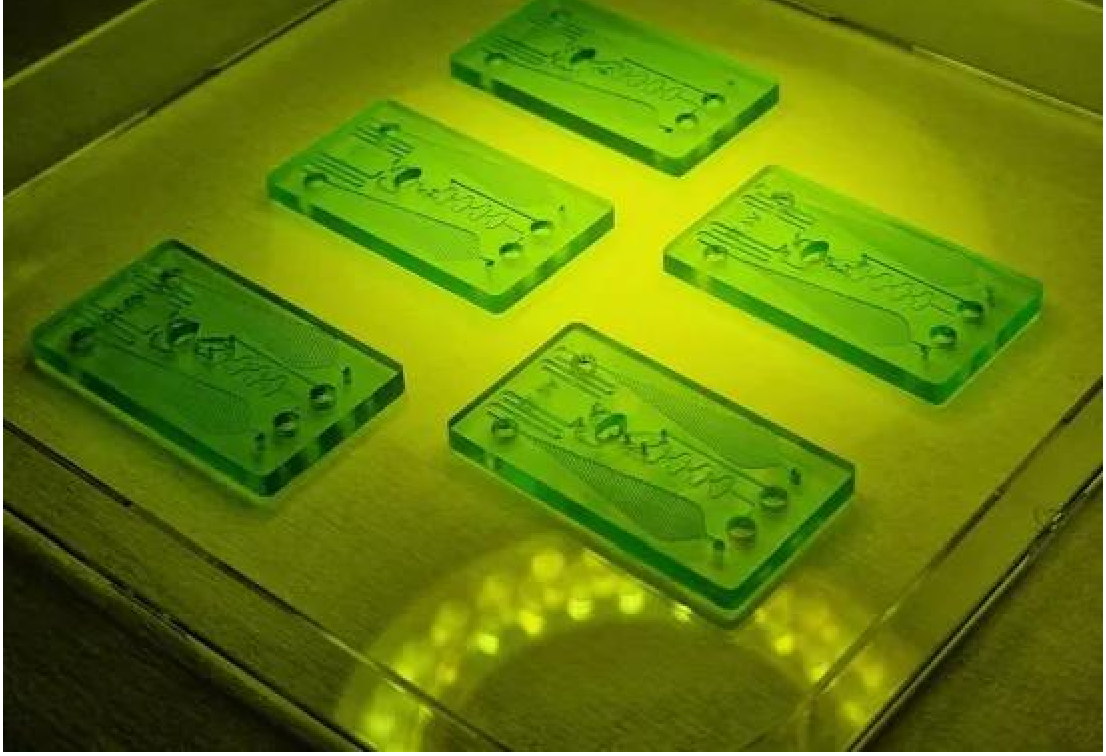

Figure 2: Micro 3D-printed microfluidic chips (process time: 40 minutes)

4) CNC micro-milling and laser micro-machining

Direct machining by CNC micro-milling is a technique that allows microfluidic systems to be created directly and with extreme precision by removing material with micro-tools. Laser micro-machining does the same but with pulsed energy beams. These techniques, which can be extended to materi [illegible] o applications where [illegible] mall production runs.

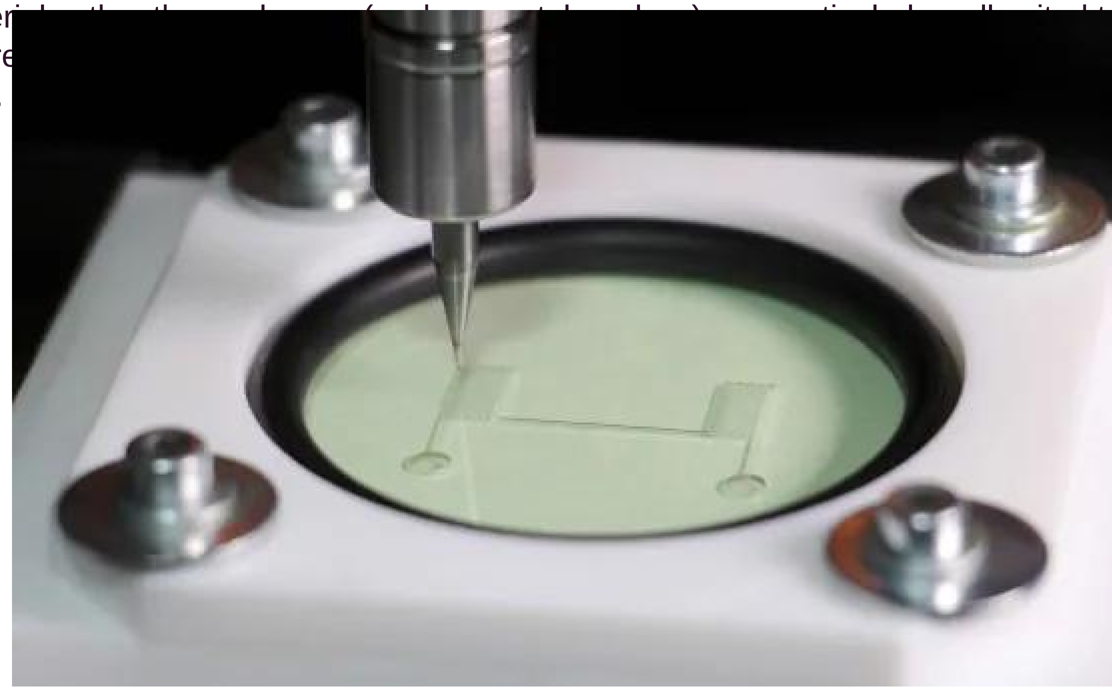

Figure 3: Prototyping by direct micro-milling

5) Micro-embossing

Micro-embossing, both isothermal and non-isothermal, offers a production method for microfluidic structures on a larger scale, both in size and quantity. In this technique, a polymer is thermoplastically deformed using a heated stamp to create microscopic structures. Micro-embossing is also suitable for small-scale production.

6) Injection moulding

Injection moulding involves injecting molten polymer into moulds to quickly and efficiently create micro … range of therm … es and at low cost.

Figure 4: Microinjection moulding of microfluidic chips

This process can use transparent materials such as COC, COP, PC, PMMA and PS as well as engineering thermoplastics such as PEEK and even more recent materials that are of biological origin and/or biodegradable (PLA). There are also thermoplastic elastomers (TPE), which are flexible. The use of auxiliary systems such as Variotherm® can increase injection moulding precision by optimising the thermal conditions of the mould.

7) Ultrasonic replicating

Ultrasonic replication is another plastic injection technique. It is distinguished by its ability to produce the kind of very fine details that are usually not possible with conventional injection moulding. In this method, the polymer is fluidised with the aid of ultrasound. This method is ideal for applications that require high resolution, although it is limited to the production of small parts.

8) Roll-2-roll

Finally, there is roll-2-roll, which is a technique that lends itself to very large-scale production of flexible and thin parts. It is a continuous stamping process using microstructured rolls.

Stamps or dies required

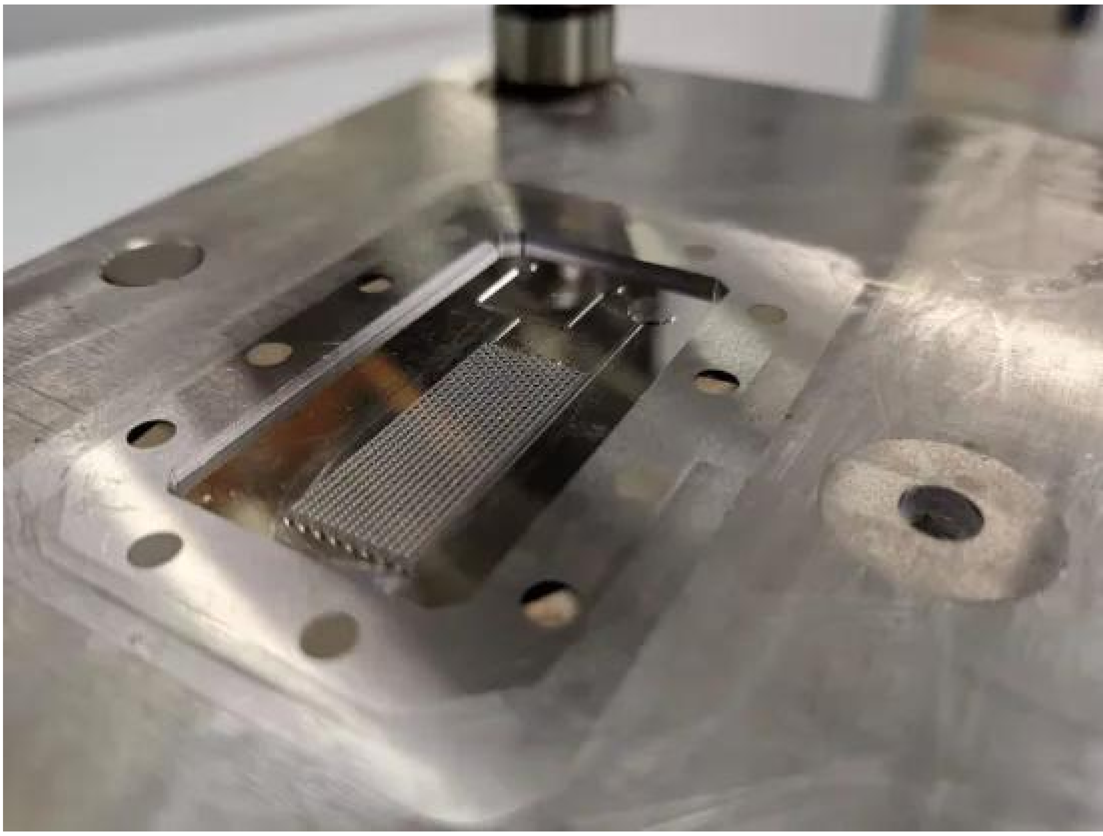

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Figure 5: Mould inserts by Ni-electroforming (top) or direct micromachining (bottom)

Sealing

All the above methods can be used to create macroscopic parts with microfluidic channels on their surfaces. To obtain a fully functional part, it is necessary to seal the part with a lid or film. The adhesion of this lid or film is crucial.

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Figure 6: Microfluidic chip with internal microchannels, sealed by solvent-based thermal bonding

Project funding

VLAIO COOCK Medical diagnostics goes micro and smart, HBC.2021.0560

More information about the project

[Medical diagnostics goes micro and smart]

Would you like to know more?

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