PDMS Microfluidics:

A beginner's guide

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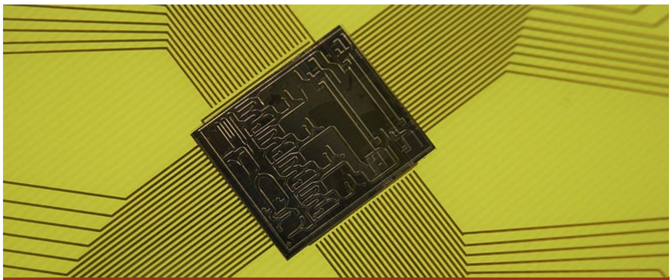
Microfluidic devices have been extensively researched over the last 30 years, from inkjet printer heads to complex medical devices that can examine tiny volumes of biological samples. The result of this research is generally towards miniaturisation, raising production yields and lowering costs, while allowing more data to be extracted from ever smaller samples.



Microfluidic chips are often produced using micromachining i.e. by etching structures in silicon or glass. This can give nanometer resolution, but the chips take a long time to produce, which is not ideal for the prototyping of simple devices!

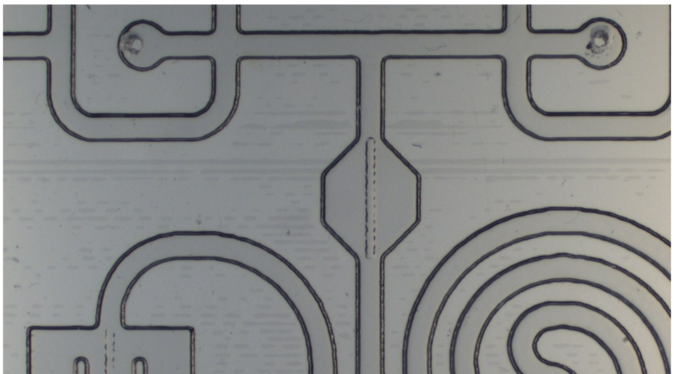
Early microfluidic devices commonly used micromachining techniques to etch channels directly in glass or silicon. However, micromachining requires complex cleanroom facilities, and the turnaround time between design and working devices can be many weeks or months.

'Soft lithography' was developed at the turn of the millenium to rapidly prototype microfluidic devices. PDMS (polydimethylsiloxane) is cured on a mould fabricated from a photoresist material, allowing tiny features (< 1 μm) to be replicated in the PDMS material. Raised features in the mould become trenches in the PDMS, and bonding the shaped PDMS to a flat surface creates enclosed channels. PDMS has since become ubiquitous in microfluidic research laboratories as it is biocompatible, transparent and flexible, and the moulds can be produced relatively quickly and used to produce multiple copies of the device.

In our laboratory, bonding is normally achieved by exposing the PDMS and glass surfaces to oxygen plasma. The treatment activates surface groups on both the PDMS and glass, and on contact these bond covalently, giving a very strong bond. This technique has become popular as it does not require glue – with very tiny channels, applying even tiny volumes of glue leads to the channels becoming blocked. For simple devices however, double-sided tape works just as well, as long as it sticks to silicone rubber and is waterproof.

A mould with microscale features requires photolithography, and its high resolution is only an advantage if you need very small features. Moulds can be created using normal machining, or by using commonly available 3D printing systems. No laboratory or expensive equipment is required!

In this tutorial you will learn the basics of working with PDMS, using simple equipment that is inexpensive and widely available. Although more complex devices are not possible without laboratory equipment, you are able to create devices for the controlled mixing of fluids, the creation of droplets of water in oil, and many other applications that would be very difficult without a microfluidic device. We hope this will encourage you to take these techniques back to your home institutions and inspire you to create your own devices!



Using the techniques outlined in this tutorial, you can create relatively complex devices that have a variety of applications.

RSC Chips and Tips Blog: **http://rsc.li/ip5tJ3**
For more information on do-it-yourself microfluidics, RSC's Chips and Tips blog has a variety of articles that outline basic but very useful techniques in microfluidics, including a number on non-laboratory PDMS chip fabrication.

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A microfluidic chip

in ten easy steps

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1. Pour 30 ml of the monomer from the tin into the beaker. Be careful as the monomer is viscous!

2. Add 3 ml of the curing agent from the bottle using a Pasteur pipette.

Once mixed, PDMS remains liquid at room temperature for several hours, and cures completely in two days. If heated to 150°C, on a hotplate or in an oven, it cures in just 10 minutes! However, care must be taken not to melt your mould!

3. Mix the two parts together for a couple of minutes using a metal spatula, until it is white and opaque with bubbles.

4. Cover the beaker and leave the mixture to degas for 2 hours.

When curing, PDMS will stick to glass and silicon, but not to plastics or metal. Silicon or glass moulds can be treated with fluorinated molecules to make the surfaces non-stick.

If available, a desiccator with a vacuum pump can be used to speed up the degassing process, by making the bubbles expand and rise to the surface quickly, but is not required.

5. Create a rectangular ‘boat’ from a double-layer of foil and place the mould into the bottom.

6. Pour the degassed PDMS in the boat, removing bubbles using a pipette tip. Put the boat on the candle hotplate.

7. After 2 hours, your PDMS should be cured. Re the foil, and then cut around the moulded PDMS and peel it away from the mould.

8. Where required, punch holes from the moulded side through the PDMS block.

9. Cover a large glass slide with the double-sided tape, this should take two strips. Remove the non-sticky upper layer.

10. Place the PDMS block, moulded side down, onto the tape. Press down to adhere the PDMS to the slide.

Congratulations, you have made a microfluidic chip! To test it, use the provided syringes to inject coloured dye into your chip, allowing leaks to be seen and making the channels more obvious.

PDMS is a biocompatible and safe for handling once cured, so take your chip home as a souvenir of the workshop!

Injecting fluid into empty microfluidics, or ‘priming’ them, is a crucial part of their use. Any trapped air can cause the chip to not function correctly, as the air is compressible and absorbs energy from the fluid flow.

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