# Novel fabrication method for rapid creation of channels using PDMS for microfluidic networks on planar substrates

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**Abstract:** A novel and simple method for the rapid fabrication of microfluidic networks is presented. A silicone elastomer (PDMS - poly(dimethylsiloxane)) is cured around formers, which are then removed post-cure, resulting in a microstructure suitable for fluidic applications. The limiting factors in the fabrication method are in the materials and tools used for the development of the formers. If the methods used cannot produce a structure of accurate dimensions then the microstructure formed will be limited. For creating very narrow fluidic channels, the material used needs to be strong so that even with narrow dimensions it can be removed without damage but the use of sacrificial materials has been investigated as this overcomes this requirement. The principle of the technique is demonstrated with an unusual material (caramelised sugar – which can be easily dissolved in water) to fabricate channels with diameters down to 16µm.

**1 Introduction:** In the microfluidic research community, narrow channels are often required for a number of reasons such as transport of fluidic medium, mixing reactants or separation channels for electrophoresis. Creating these narrow microfluidic channels often requires the use of specialist equipment or clean room facilities. The method presented here, whilst it may not be applicable to all microfluidic applications, enables the rapid fabrication of microfluidic structures using only basic laboratory apparatus.

**2 Fabrication:** For rapid prototype and development, PDMS is a very useful material. We used the Sylgard 184 elastomer kit; which is a two part mix. Curing the PDMS can be done in as little as 10 minutes at 150°C, or if left at room temperature it can take up to 48 hours. After mixing we place

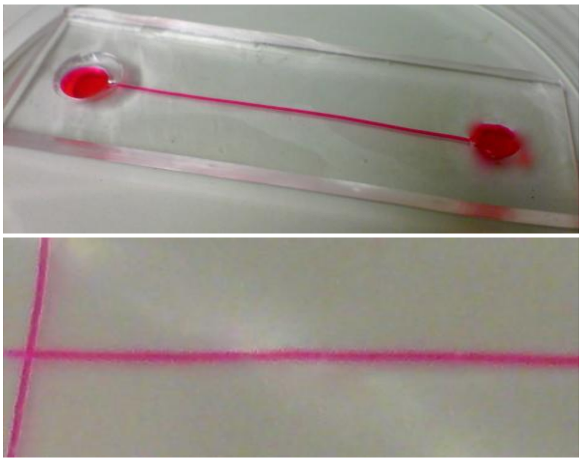

Fig. 1. Photographs of microfluidic channels created by removing wires from PDMS. Top: 600µm diameter channel. Bottom: 180µm diameter channel

the PDMS in a vacuum desiccator to remove any bubbles from the mixture.

One method of fabrication which showed success was using a thin metal wire (as the former of the channel) placed on the heads of two nylon bolts and surrounding with PDMS in a Petri dish. The PDMS is cured on a hot plate at 80°C for 1.5 hours; the use of a plastic Petri dish limits the maximum curing temperature. A plastic Petri dish was chosen over glass because the cured PDMS can be easily peeled from the plastic Petri dish; this is not true of glass. After curing, the nylon bolts can be pulled out revealing the underlying wire. Pulling the wire with a gentle force removes it, leaving behind a complete channel, the diameter of which is approximately equal to the diameter of the wire. A photograph of an enclosed straight channel, with a diameter of 600µm is shown in Fig. 1. The width of the wires used is relatively large since thinner wires are more prone to breaking upon removal. Initial experiments with the wires showed success at making channels with diameters

A: Before removal of formers and dissolving caramel strands

B: Photographs of a red dye through channels after the caramel is dissolved

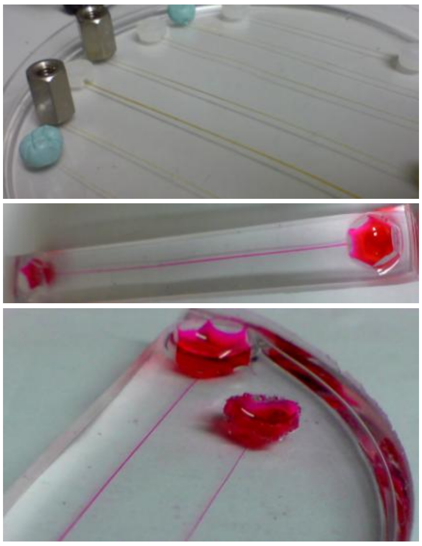

Fig. 2. Examples of channels produced using sacrificial caramel strands.

down to 180µm; a photograph of which is shown in the bottom of Fig. 1.

Occasionally the removal of the wire causes damage to the channel, thus sacrificial layers defining the channel were investigated. For initial tests, caramel strands (a water soluble material) were used, which proved effective. Granulated sugar was heated to 250°C until it caramelised and then long strands were drawn. Longer strands resulted in more uniform dimensions. The strands were then placed on a flat cured layer of PDMS; structures were then placed on the ends of the caramel strands to form the reservoirs at either end. After curing the PDMS, the end structures are removed, and the PDMS is placed in a beaker of deionised water and left until all the caramel dissolves. The process takes less than 24 hours; refreshing the bulk deionised water and agitating the beaker accelerates this process. Fig. 2 shows some examples of the types of channels that can be fabricated using this method.

**3 Results:** Using wires as the channel formers, produced channels with diameters down to 180µm. Whilst this is relatively large and the channels are not perfectly straight, this method is simple and suitable for rapid creation of fluidic transport networks on microfluidic devices. A limitation is that only straight or near-straight channels can be created, due to the requirement to pull the wires out.

A variety of different thicknesses of caramel strands were created for use in the fabrication of microchannels; the narrowest channel produced is shown in the bottom of Fig. 2 and measured 16µm in diameter. For comparison, Duffy *et al.* [1] reported a microfluidic network of channels in PDMS with widths >20µm. The fabrication method they used yielded a rectangular cross-sectional area rather than circular. Similar channels were formed by Ros *et al.* [2] by using a microfabricated masterwafer; this enabled the fabrication of channels with dimensions 50µm x 6.5µm. Although more work is required to improve strand width repeatability, this technique has been shown to work well, and is both useful and practical for making generic channels.

**4 Conclusions:** This novel fabrication method enables the rapid development of microfluidic channels and structures using only basic laboratory tools and materials. Whilst casting around wires has been demonstrated to be practical, the promising results with novel sacrificial caramel strands illustrate the usefulness of the principle of sacrificial layers for the development of microfluidic channels. Further investigation into other sacrificial materials and production methods will yield improved channel uniformity and enable the fabrication of smaller diameter channels. Only straight channels have been described here; however the sacrificial layer could be shaped to more complex geometries for a variety of different microfluidic applications.

## Acknowledgements

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## References

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