Making microchannels with a hobby 3D-printer: difficult but possible

3D-printing has been used to make microchannels for the last few years, but common hobby 3D-printers have not been considered capable of making usable channels due to low quality. However, this study has made 400 µm wide channels with less than 15 µm variation in width using a cheap hobby 3D-printer, showing that such printers could in fact be used to make microchannels. Achieving such quality consistently is nonetheless still a challenge.

Fluids behave differently on microscopic scales than on macroscopic scales. This so-called microfluidic behaviour is distinguished by being more orderly and consistent than the flow in for example a stream. This, along with other effects that become significant at microscopic scales, can be used to perform medical and chemical tests using centimetre sized chips instead of bulky lab equipment. A more advanced version of such chips could perform more advanced lab tests, making it a so-called lab-on-a-chip.

One way of making these microfluidic chips is using 3D-printing, which has become more common in the last decade as the resolution of the technology has improved. The type of 3D-printing that is most commonly used is stereolithography, which forms 3D objects by solidifying layers of UV-curable liquid resin with a laser. Stereolithography has a good resolution, but the types of material that can be made from such resin are quite limited.

An attractive alternative to stereolithography is fused filament fabrication (FFF), a different type of 3D-printing that is common in hobby printers. Instead of using a resin, FFF essentially “draws” objects with molten plastic layer by layer. This gives much more freedom in what materials can be used, as FFF can in principle make things from any material that can melt.

FFF does however have a big drawback; the fabricated objects have a large number of small surface defects. While these are mostly too small to be noticeable on macroscopic scales, they can be large enough to block the microchannels on a microfluidic chip. This has limited the usefulness of FFF when making such chips.

The goal of this project was to see if the defects in FFF can be reduced by adjusting the settings governing the printing process. The focus was on how the defects affect the width of small channels. This was measured by making 0.4 mm wide channels using a cheap hobby 3D-printer and photographing the channels with a microscope for digital analysis.

This analysis showed that none of the settings tested, such as speed, temperature and layer height, had any significant effect on how much the defects caused the width of the channels to deviate from their average width. The only possible exception is layer height, where a layer height of half of the nozzle diameter seems to minimize the amount of channel width variation, but the evidence for this is not very strong. Still, it suggests that it would be interesting to investigate the correlation between channel width variation and layer height further.

While no clear way of reducing the variation in the channel width was found, the variation was quite small in some of the channels made. In the best channels, the width did not deviate by more than 15 µm, which is within acceptable tolerances for large microchannels. What caused this good quality is however not known.

In summary, this project has shown that FFF can achieve quality good enough to make microchannels, even using a cheap hobby printer. More research is however needed to determine how to achieve such quality consistently.