Feature Based Design Software for 3D Printed Microfluidics

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The use of 3D printers and additive manufacturing has reached a point where there are prototype printed cars and consumer grade 3D printers available for under $1000. With the broad range of applications already available, people are starting to look at new industries in which this technology can make an impact. Starting in 2002 the Whitesides lab demonstrated the use of 3D printing as a way to construct molds for microfluidic device fabrication.[1] Other groups have followed suit, using 3D printing to either write molds for casting or directly creating microfluidic devices. Microfluidics manufacturer, Dolomite, has also followed the trend with their 3D printer designed for fluidic device fabrication, the Fluidic Factory. All of these technologies rely on conventional computer aided design (CAD) software. The robustness of such software packages allows for great freedom of design, but suffers from a steep learning curve.

The software described here simplifies the design process by providing a selection of common parameterized microfluidic features that the user can choose through a GUI. By combining simple features, users can quickly design a complete microfluidic chip that provides unique functionality. The software provides the g-code required to operate an inexpensive filament extrusion 3D printer. PDMS is then cast over the ABS master and cured using the printer’s heated print bed. The PDMS device can be peeled off the print bed and the ABS mold is easily removed. Conventional soft lithography steps are taken to bond the device to glass. Figure 1 shows a flow diagram of this fabrication process. This comprehensive approach for utilizing 3D printer technology for the development of microfluidics provides three distinct advantages. First, the design software provides adequate design freedom while improving the accessibly of microfluidic

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[1] J.C. Mcdonald, M.L. Chabinyc, S.J. Metallo, J.R. Anderson, A.D. Stroock, and G.M. Whitesides, Anal. Chem. **74**, 1537 (2002).

technologies to those not familiar with conventional VLSI or solid modeling tools. Three-dimensional fluidics can be readily fabricated without roughness that comes from the conventional layering processes. Finally, the final device materials, PDMS bonded to glass, have been extensively studied and the advantages and drawback of this material are readily understood within the microfluidics community. Figure 2 shows a finished device filled with food coloring showcasing 3D capabilities.

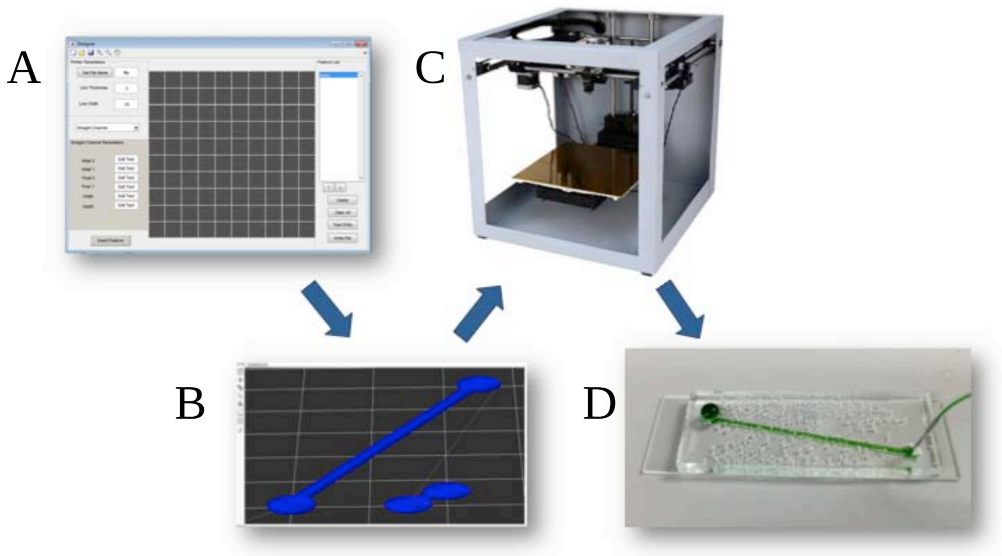

Figure 1: Workflow diagram showing how the design software works A) A Matlab GUI shows features that are selected and assembled into a complete device. B) The resulting g-code is loaded into Repetier Host, a 3D printer interface software. C) The design is printed on a filament extrusion 3D printer. PDMS is cast over the mold, cured with the heated print bed, and removed from the print bed. D) The ABS mold is removed from the PDMS device, inlet and outlet holes are punched in the PDMS and the device is plasma bonded to a glass slide.

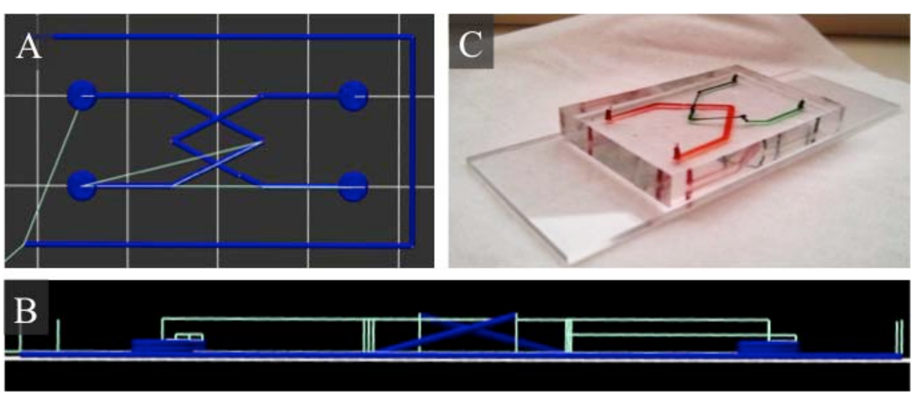

Figure 2: Feature based design allows for continuous printing of 3D features rather than conventional layering methods, resulting in smooth, continuous channels. A) Top view of the device in Repetier Host. B) Side view of the device in Repetier Host. C) Molded and bonded device filled with food coloring.