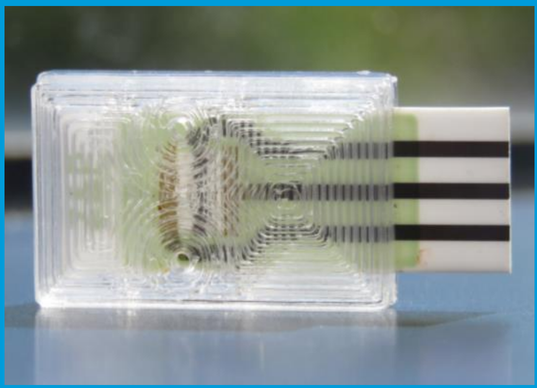
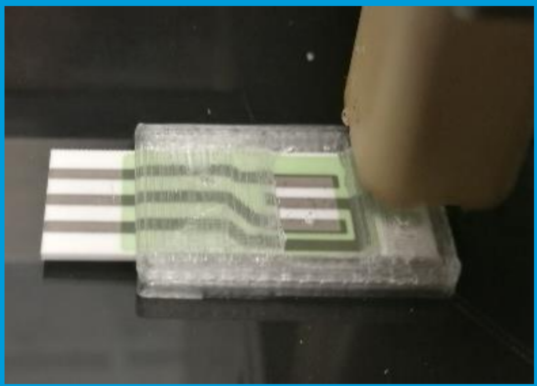
# Fluidic Factory “Pause” Function

## Use of “pause” function for the design of a flow cell for electrochemical sensor testing





## Aim & Objectives

This work demonstrates the experimental capability of the Dolomite Fluidic Factory 3D printer machine by showing an application for pause software function. This function is used to embed an electrochemical sensor within a COC 3D printed fluidically sealed flow cell.

## Introduction

Traditional fabrication techniques in the fluidic/microfluidic industry are too slow and expensive for a prototyping approach. So far, common 3D printing was not suitable for the microfluidic community, mainly because existing customer-grade printers focus on the external appearance and cannot deliver properly sealed channels embedded into a chip. Dolomite Microfluidics has developed the Dolomite Fluidic Factory, a highly innovative tool to enable FDM (fused deposition modelling) printing of microfluidic devices and overcome traditional challenges of 3D printing. Compared to other 3D printing techniques FDM is generally cost-effective and fast, and hence ideal for microfluidic rapid prototyping. Two key innovative features ensure fluidic sealing:

1. The software analyses the 3D geometry of the device and identifies the internal voids and surfaces. The print paths are then created from the inside of the device outwards and the print head deposits filaments in a continuous, leak-proof manner.
2. Fluidic Factory's clever design allows filaments to melt together when depositing on top of each other. A small volume of polymer (60 µL) is melted to a fluid state at very high temperatures and only held a few seconds before ejecting and depositing in a 'squashed' manner (Figure 1). This ensures excellent adherence, optimal polymer quality and leak-free channels.

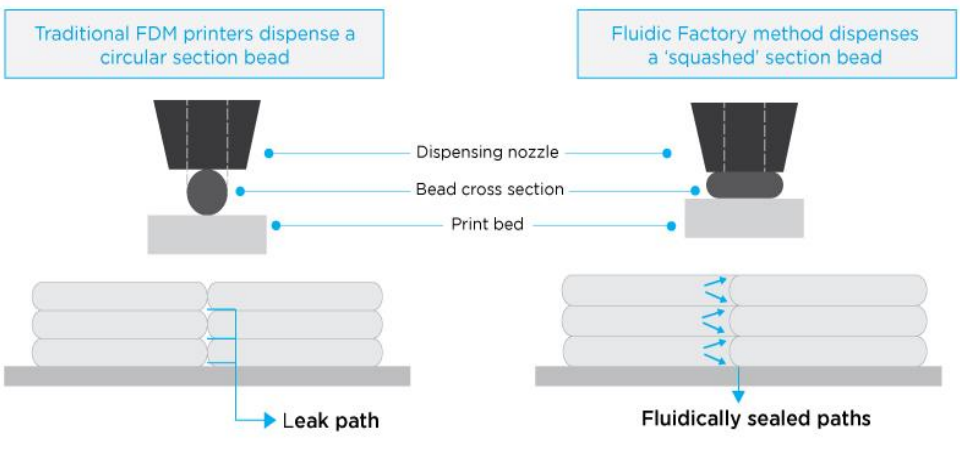



*Figure 1. "Squashed" bead FDM printing method.*

Cyclic olefin copolymer (COC) has been identified as the optimum polymer for the Fluidic Factory due to its unique properties: FDA approved, optically transparent, non-auto fluorescent, excellent chemical resistance, and biocompatible. It is a critical material for microfluidics in biology and medical environments.

Several fluidically sealed chips can be printed with the Fluidic Factory using the software standard settings. Moreover, an important software function further expands the range of applications of the Fluidic Factory 3D printer compared to other printers based on FDM methods. This function is the “Pause” function, which allows the integration of external elements within the printed geometry. The function will be examined in the following section in a specific case of study.

## Pause Function (Case of Study)

In this section, we show how to use the Fluidic Factory “pause” function to encase a standard electrochemical sensor within a 3D printed flow cell. The electrochemical sensor used is a Zimmer & Peacock biosensor (https://www.zimmerpeacocktech.com/knowledge-base/faq/3d-printed-biosensors/) which provides a quick and accurate way of determining concentrations of bio-relevant molecules (Figure 2).

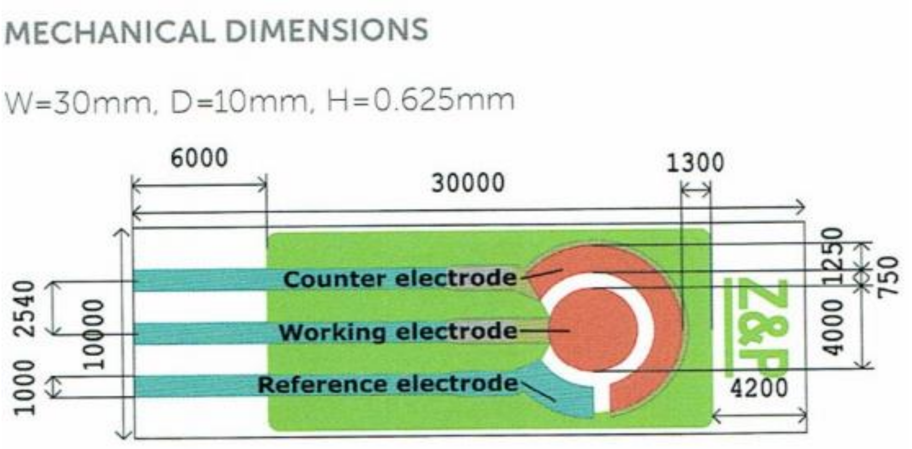



*Figure 2. Dimensions of C-ADGG-101-N Z&P sensor.*

The flow cell is a microfluidic chamber with one inlet and one outlet for fluid access (Figure 3). The geometry is specifically designed to fit the sensor geometry. The flow chamber has the same dimensions (no gap) of the rectangular sensor to ensure a fluidically sealed structure.

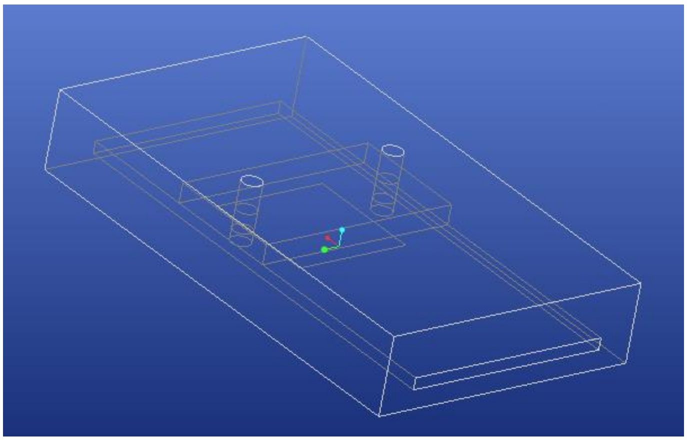


*Figure 3. Flow cell CAD design.*

The sensor-flow cell hybrid device is assembled by sandwiching the alumina sensor substrate within the 3D printed flow cell. The Fluidic Factory software “pause” function allows users to stop the printing process at a specific level to insert the electrochemical sensor element. The remaining part of the flow cell is then printed on top of the sensor to fabricate a fluidically sealed hybrid structure for electrochemical sensor testing (Figure 4).

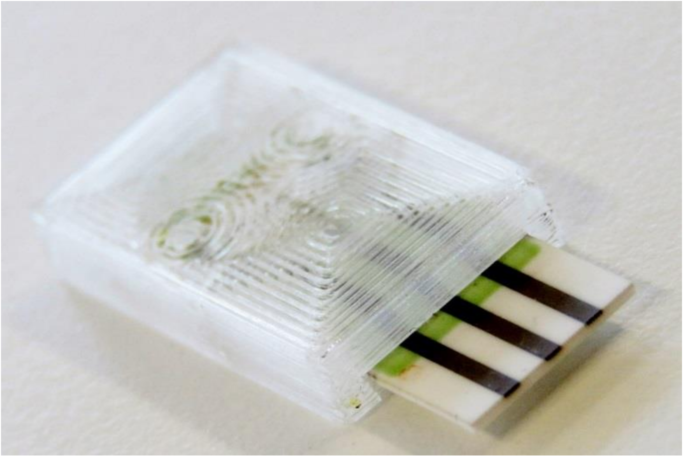
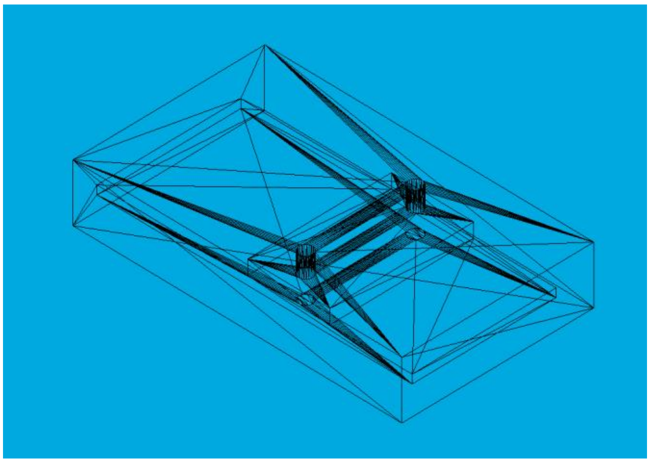


*Figure 4. Hybrid microfluidic device flow cell for electrochemical sensor testing.*

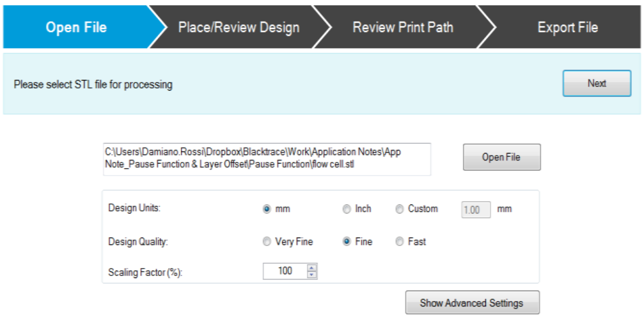
To pass from the CAD geometry of Figure 3 to the final hybrid device of Figure 4, the following steps are required:

**(1)** The CAD file is converted and saved as stl format.



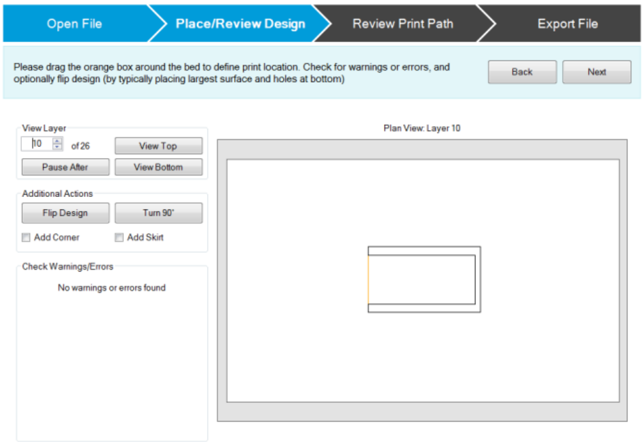
**(2)** The stl file is uploaded on the Fluidic Factory software. Fine quality mode and 100 % scaling factor are selected.

Press “Next”.



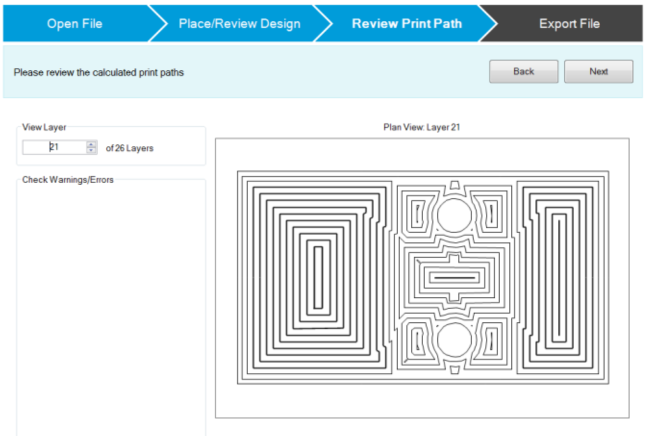
**(3)** The final chip is made of 26 layers of COC polymer beads arranged in a 3D structure (the different layers can be viewed using the top/down arrows). By default, the chip is printed with the inlet and outlet ports facing the print bed. By selecting “flip design” the printing orientation is reversed. “Pause after” is introduced at the 10th layer. This will allow the user to introduce the electrochemical sensor afterwards.

Press “Next”.



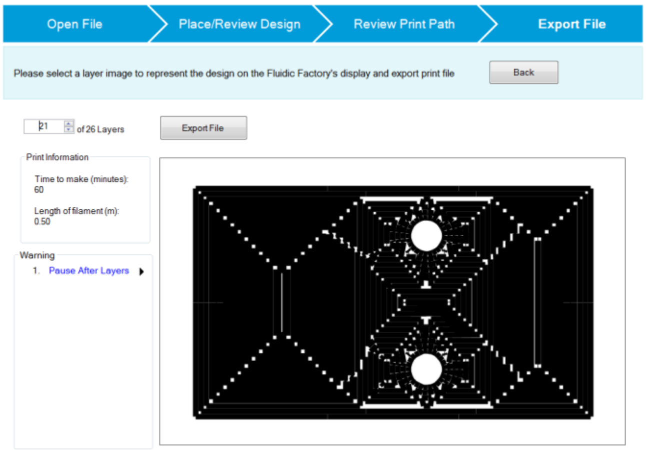

**(4)** The print path is reviewed.

Press “Next”.




**(5)** The print path is generated. Two different phff files are produced. The first file allows printing the bottom side part of the chip (from layer 1 to 10). The second file allows printing the upper side part of the chip (from layer 11 to 26).

Press “Export File”.



The two phff files are named and saved on a USB pen drive which is then plugged to the Fluidic Factory USB port. Using the Fluidic Factory interface, we print the first-half of the chip (Figure 5a). Once the first-half is printed, the print head moves laterally and the print bed cool down. This allows the user to manually place the electrochemical sensor element within the bottom chip geometry (Figure 5b). After that, the top second-half of the chip is selected and printed to include the sensor giving the final hybrid microfluidic flow cell device. (Figure 5c).

a) Bottom First-half Chip from layer 1 to 10

b) Sensor Positioning at layer 10

c) Top Second-half Chip from layer 11 to 26

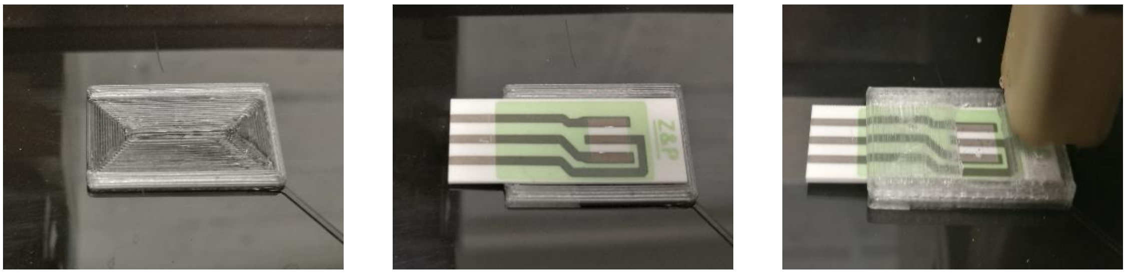


*Figure 5. Flow cell hybrid device printing.*

The final structure is removed from the print bed and tested by flowing some red dye using a common pipette (Figure 6).

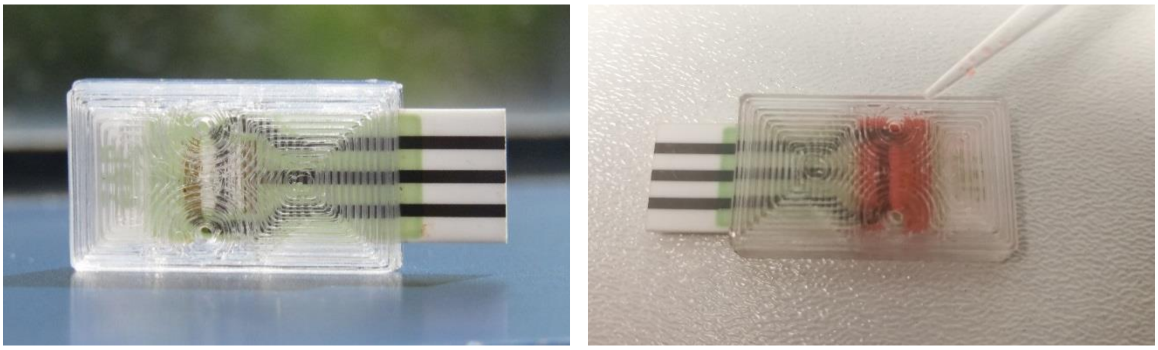


*Figure 6. Flow cell hybrid device.*

To check if the entire structure is fluidically sealed a leaking test is performed by leaving the red dye within the flow cell chamber for 24 h. The result shows that no leakage occurs between polymer layers and at the sensor-polymer interface. To conclude, the final hybrid structure can be used as potential easy and cheap solution for electrochemical sensor testing.

## Other Examples

Pause function is used to encase a perfluoroelastomer gasket within a resealable chip structure for cell culture and organ on a chip applications (Figure 7):

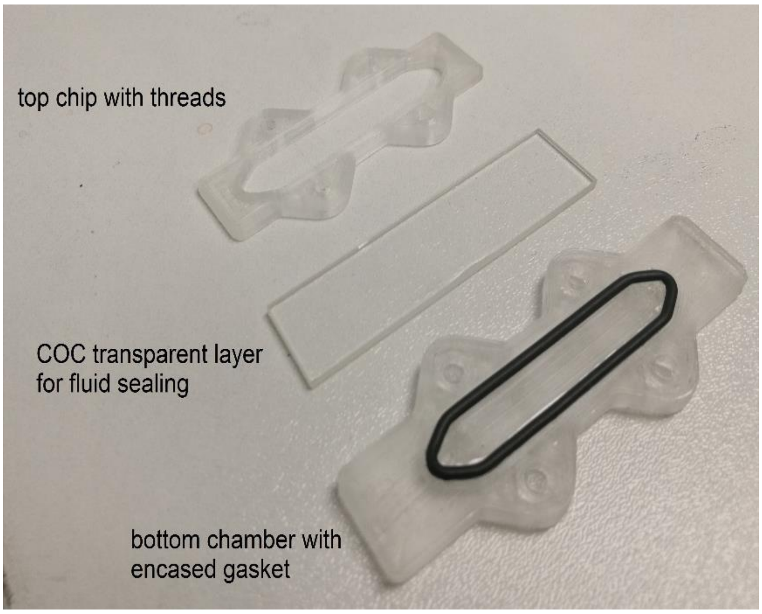



*Figure 7. Resealable chip with encased gasket.*

A combination of pause function and layer offset function is used to print a step-like Y-junction chip on top of a COC transparent substrate able to fit a Dolomite Top Interface 4-way (4mm) (Part No. 3000109) and Dolomite Linear Connector 4-way (Part No. 3000024) (Figure 8).

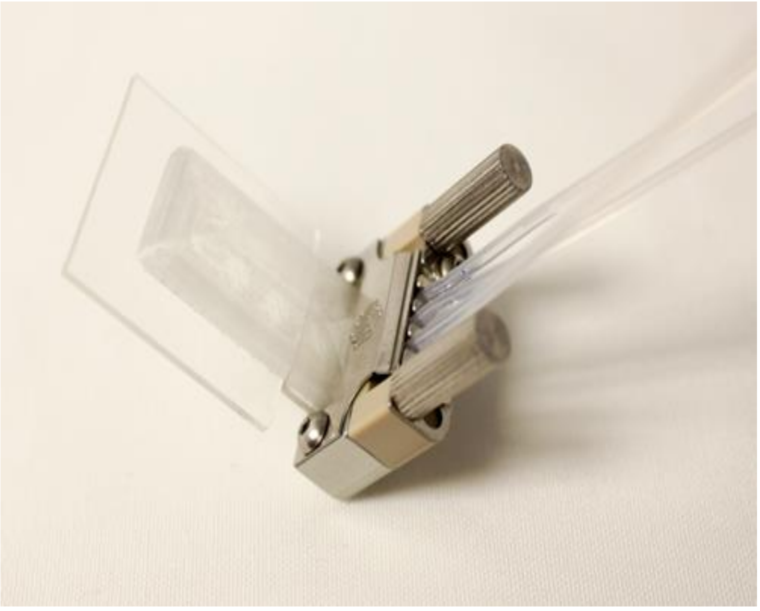


*Figure 8. Y-junction on COC substrate fitting Dolomite connectors.*

## Conclusions

This application note showed the experimental capability of the Dolomite Fluidic Factory 3D printer by describing the use of the software pause function. The pause function allows the user to stop the 3D printing process at a specific layer and gain physical access to the print bed. External components such as biological material, chemicals, membranes, etc can be manually positioned within the partially printed structure, before completing the printing process. This function is particularly useful to create fluidically sealed hybrid-sandwiched structures. As example, in this application we showed how to encase an electrochemical sensor in a 3D printed flow cell structure.

The pause function expands considerably the range of capability of the Fluidic Factory printer compared to the other printers based on fused deposition modelling techniques.