Electronic Supplementary Information

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Electronic supplementary information (ESI) for Lab on a Chip

New flow control systems in capillarics: *Off* valves

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Part I: Supplementary figures

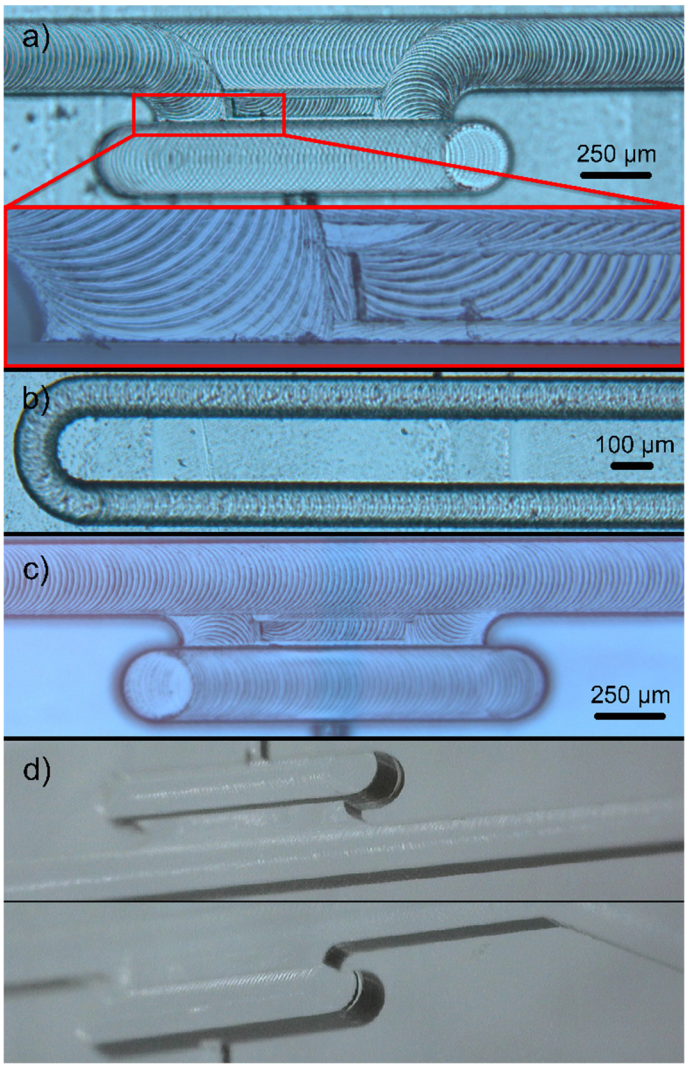


Figure S1: Results of the microscope analysis of milled channels. (a & b) Channels right after milling. (c) A channel after cleaning and PMMA coating. (d) Tilted views of the same valve for side wall quality control.

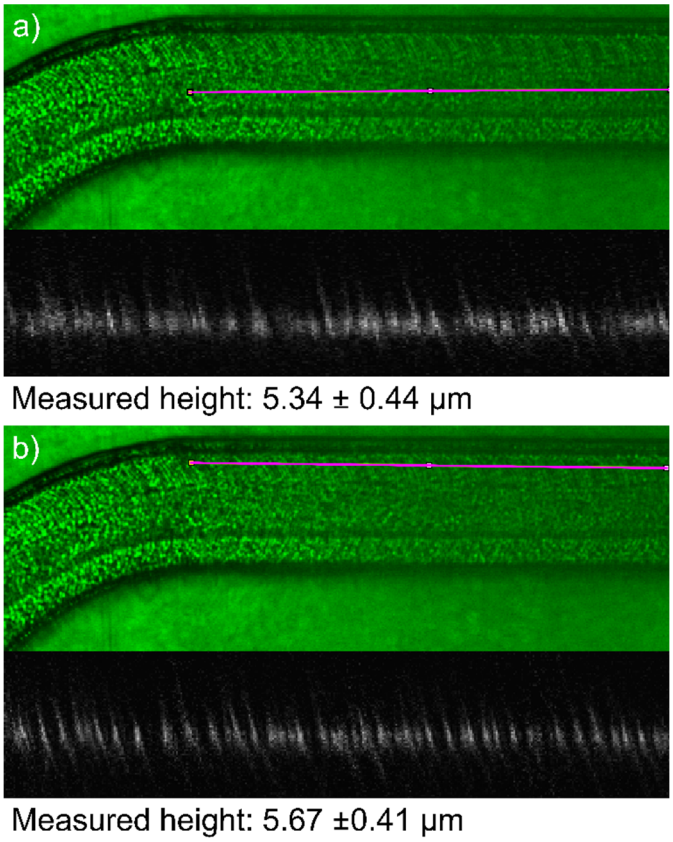


Figure S2: Confocal imaging and Reslice analysis by ImageJ to determine cutting roughness. Two different zones were measured (a & b), as height may be dependent on the cutter position. The height was determined by measuring the distance of the top of bright zones to the bottom of the next.

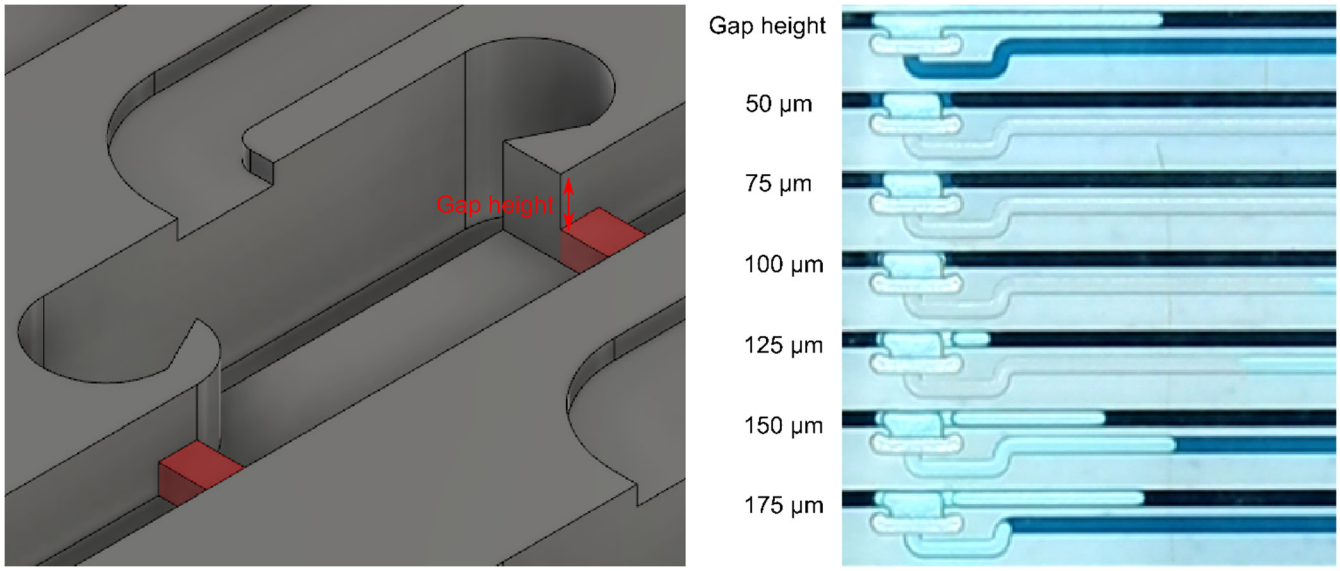


Figure S3: *Off* valve with barriers (marked in red) to inhibit bubbles from entering the main channel as schematic CAD image and the results of a gap height screening experiment. While in most cases the 175 µm gap height successfully hindered the bubble from entering into the main channel, this was found to be unreliable. Only gap heights ≤ 100 µm showed 100% reliability.

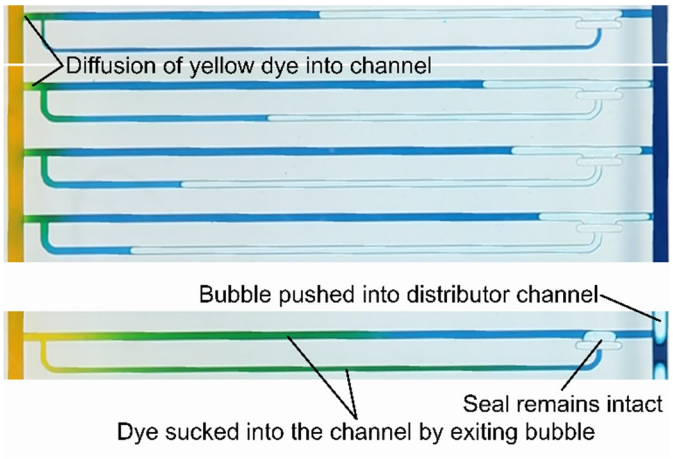


Figure S4: Top-down image sequence of the seal quality test after 5 min. Blue liquid was removed and yellow liquid was added to the vents to create a counter-pressure. Some dye diffused into the channels, but significant flow was not observed in this experiment. In two of the channels, the bubble was pushed into the distributor channel.

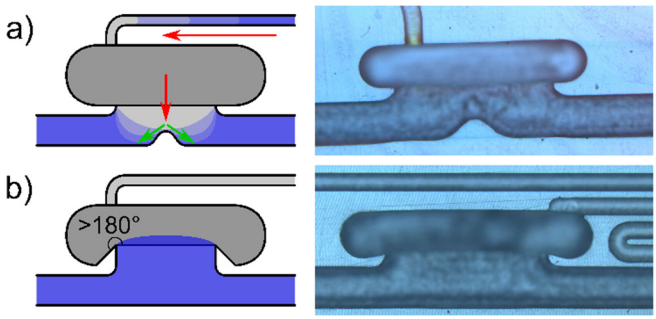


Figure S5: Optimised *off* valve designs. (a) Design that features a dent to improve sealing quality by using a radius that assists the meniscus to recede (green arrows) as a result of surface tension. (b) Alternate design to stabilise the meniscus, which is especially useful for liquids with low surface tension.

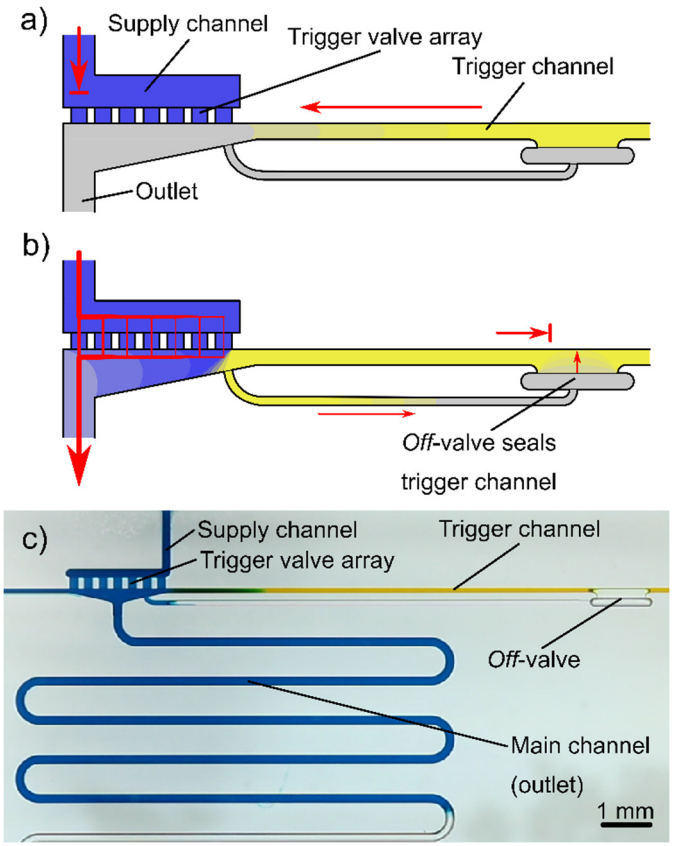


Figure S6: Schematic and operation of the releasing switching valves. (a) Upon filling, the supply channel meniscus stopped at the array of trigger valves. (b) Flow from supply channel to outlet was released once the trigger channel is filled. The dimensions of the releasing valve were chosen so that the flow resistance from the supply channel to the exit channel was significantly lower than through the trigger channel. By adding an *off* valve to the trigger channel, the return path through the channel could be completely blocked. (c) Top-down photograph of a fabricated release valve with *on off* valve integrated into the trigger channel in the triggered state. Note: The trigger valve array geometry shown in (c) was designed so that the trigger channel could continue to trigger other valves.

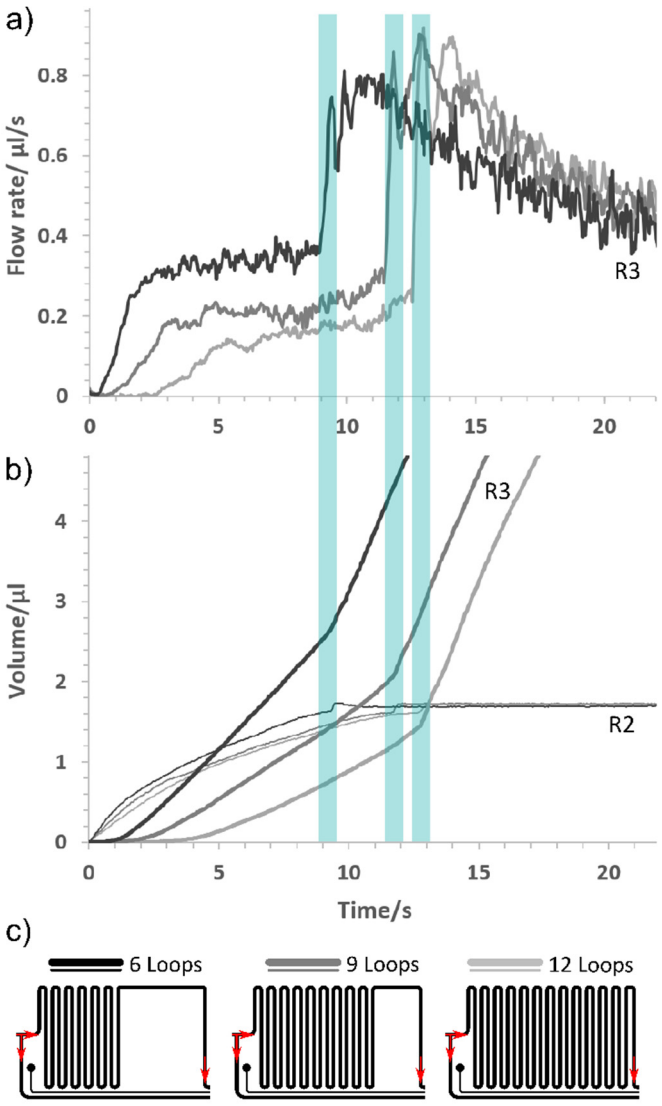


Figure S7: Variation of the first resistor (R1) to measure the influence of the bridged circuit and its resistance. (a) Plot of flow rates through the evaluation resistor, R3. (b) Plot of corresponding liquid volumes for R3 and trigger channel R2. The latter was added to visualise the timing of the triggering event. (c) Schematic showing the channel outlines of the different configurations of R1 in the circuit. Lower R1 resistances lead to increased initial flow, faster triggering and a smaller difference in flow rate through the triggering event. Time t=0 was defined as the point at which water entered the trigger channel. Noise in the flow rate data is a result of the binarisation method used, and therefore increases with capillary filling. The timing resistor (R2) was set to six loops for all measurements.

Part II: Supplementary movies

Movie V1: "*Off* valve screening" contains the video results for the screening of valve closing times as a function of trigger channel depth, described in Fig. 2. Additionally, it contains experimental results for different *off* valve depths.

Movie V2: "Sealing experiments" contains the video results for the sealing quality experiments as a continuation of Movie V1.

Movie V3: "Related designs" contains the video results of other valve designs. One branching and three *off* valves are shown. One of the latter did not work correctly as dust blocked the second trigger channel, but it was retained in the video as reference for the sealing experiments.

Movie V4: "Connecting switching with *off*-valve" contains the video results for the connecting switching valve shown in Fig. 4.

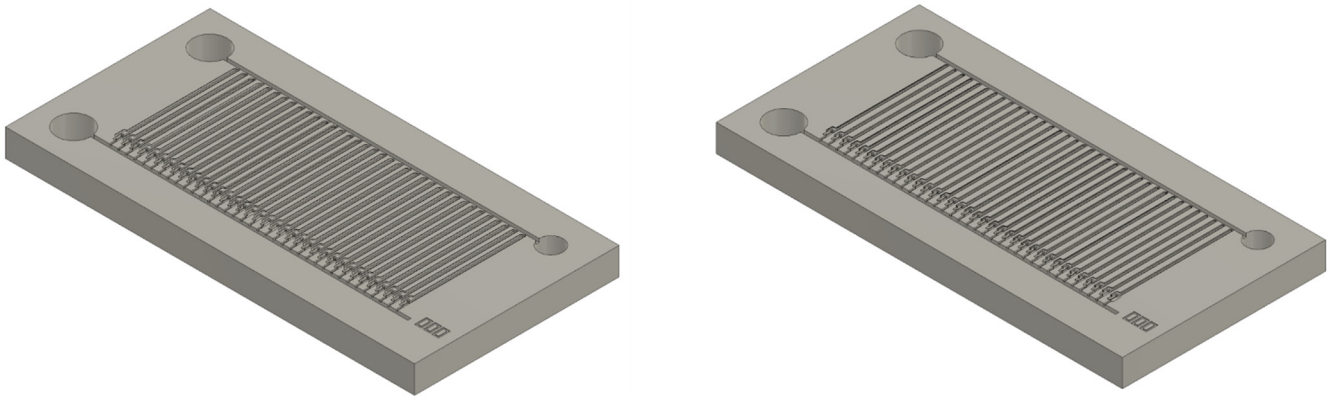
Movie V5: "Releasing valve" shows the operation of a releasing valve, as also shown in Fig. S6(c).

Movie V6: "Resistor R2 screening" contains the video results for the trigger timing screening shown in Fig. 5.

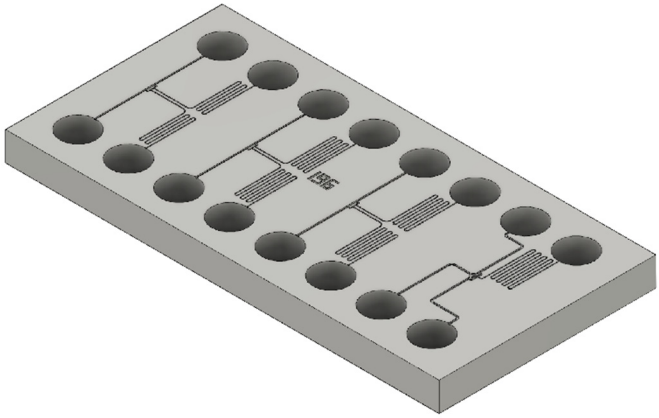
Movie V7: "Resistor R1 screening" contains the video results for the flow resistance screening shown in Fig. S7.

Movie V8: "Sequential filling" contains the video results for the sequential chemical loading into a reaction chamber shown in Fig. 6. Note: The small connection in the capillary pump is an unintentional production error, but does not disrupt the experimental concept.

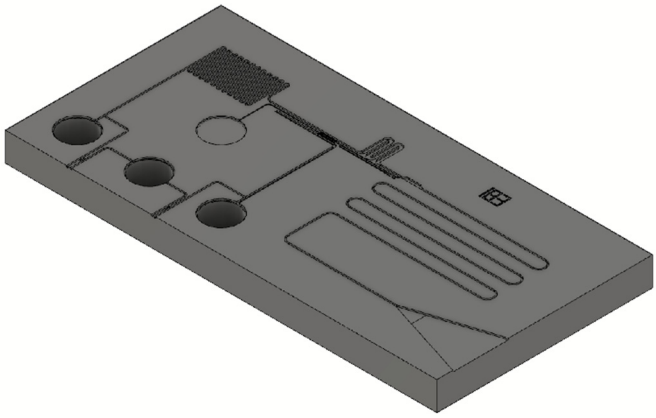
Part III: Supplementary CAD files



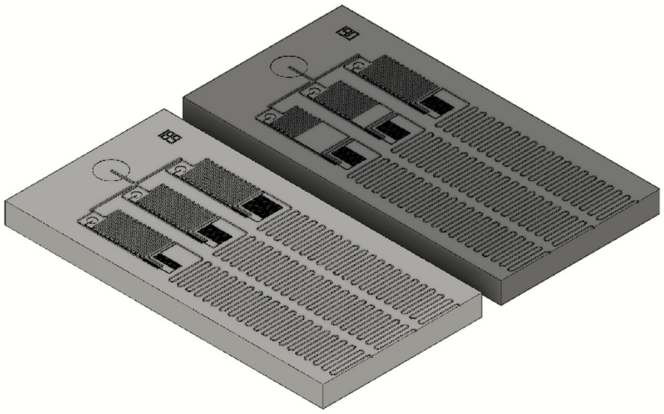
File CAD1a & b: "*Off* valve screening" contains the setup for the screening of closing valves described in Fig. 2.



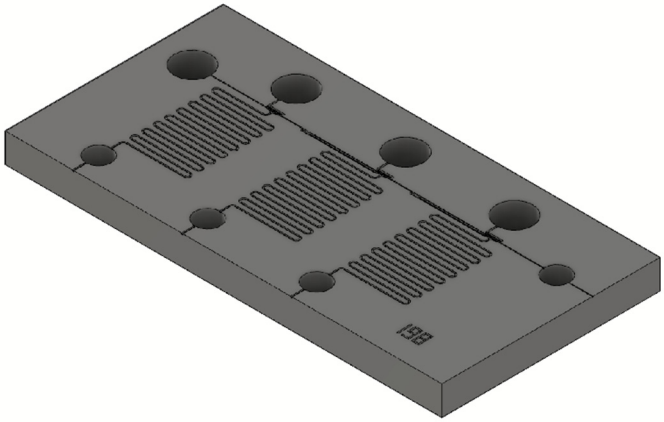
File CAD2: "Related designs" contains the setup for three *and-off* valves with varying geometry and the branching valve described in Fig. 3.



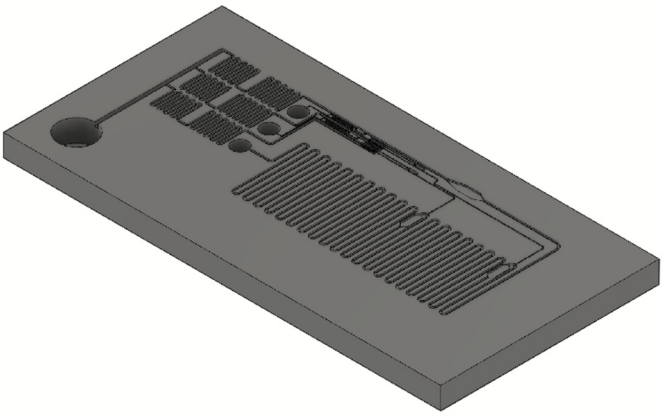
File CAD3: "Connecting valve with *off*-valve" contains the setup for the experiment described in Fig. 4. It features an inlet area with a pressure compensating connection.



File CAD4: "Connecting valve- flow rate experiments" contains the setup for the resistor and timing screening of connecting valves described in Fig. 5.



File CAD5: "Releasing valve" contains the setup for different types of releasing valves.



File CAD6: "Sequential loading" contains the setup for the automated sequential loading described in Fig. 6.