**Supplementary Information**

**Autonomous capillary microfluidic devices with constant flow rate and temperature-controlled valving**

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**SI.1 Temperature sensor characterization**

The temperature sensor characterization is done as described in the experimental part. **Fig. S1** shows the measured resistance and linear fit of the sensor. It shows a sensitivity of 0.0495 ꭥ/°C and an offset of 20.948 ꭥ. The linearity, R2 is 0.9994.

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**Fig. S1** Temperature characteristic of the temperature sensor.

**SI.2 UV-induced surface grafting of PNIPAm on PDMS mediated by benzophenone**

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**Fig. S2** Schematic drawing of UV-induced surface grafting of PNIPAm on PDMS.

**SI.3 Fluorescent dye concentration as indicator for Benzophenone concentration in the different channel walls**

We used the fluorescent Rhodamine 6 G at an equal concentration with Benzophenone photoinitiator in acetone as a concentration indicator1. The channel was filled with Rhodamine 6 G-acetone for 5 min followed by a deep wash of the channels with DI water. After washing, a fluorescence microscope image was captured using Olympus IX51 with a FLIR Grasshopper®3 color camera. As shown in **Fig. S3**, results indicate that the concentration of benzophenone in the bottom PDMS layer is much higher than in the top wall and side walls.

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**Fig. S3** Fluorescent Rhodamine 6 G in the PDMS channel walls.

**SI.4 Material properties used in the numerical simulation**

The material properties from the COMSOL 5.5 library were used;

*PDMS*;

**Density , ρ** : 970 *kg/m3*

**Thermal conductivity, k**: 0.16 *W/(m·K)*

**Heat capacity, Cp**: 1460 *J/(kg·K*)

*Borosilicate (Glass)*:

**Density, ρ** : 2230 *kg/m3*

**Thermal conductivity, k**: 1.13 *W/(m·K)*

**Heat capacity, Cp**: 754 *J/(kg·K)*

*H2O (Water)*:

**Density, ρ** : 345.28+5.749816\*T^1-0.0157244\*T^2+1.264375E-5\*T^3 *kg/m3*

**Thermal conductivity, k**: -0.9003748+0.008387698\*T^1-1.118205E-5\*T^2 *W/(m·K)*

**Heat capacity, Cp**: 4035.841+0.492312\*T^1 *J/(kg·K)*

*Air (gas)*:

**Density, ρ** : 352.716\*T^-1 *kg/m3*

**Thermal conductivity, k**: -8.404165E-4+1.107418E-4\*T^1-8.635537E-8\*T^2+6.31411E-11\*T^3-1.88168E-14\*T^4 *W/(m·K)*

**Heat capacity, Cp**: 1010.97+0.0439479\*T^1-2.922398E-4\*T^2+6.503467E-7\*T^3 *J/(kg·K)*

**SI.5 Mesh details numerical simulation**



Fig. S4 a) overview geometry numerical simulation with mesh. b,c,d) details of mesh structure. The mesh has 4 levels i,ii,iii,iv indicated in the figure.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mesh (i) | Settings   | **Description** | **Value** | | --- | --- | | Minimum element size | 0.1 μm | | Maximum element size | 2 μm | | Curvature factor | 0.2 | | Curvature factor | Off | | Resolution of narrow regions | Off | | Maximum element growth rate | 1.05 | | Maximum element growth rate | Off | |
| Mesh (ii) | Settings   | **Description** | **Value** | | --- | --- | | Maximum element size | 5 μm | | Minimum element size | 1 μm | | Curvature factor | 0.2 | | Curvature factor | Off | | Resolution of narrow regions | Off | | Maximum element growth rate | 1.3 | | Maximum element growth rate | Off | |
| Mesh (iii) | Settings   | **Description** | **Value** | | --- | --- | | Maximum element size | 1600 | | Maximum element size | Off | | Minimum element size | 10 μm | | Curvature factor | 0.5 | | Curvature factor | Off | | Resolution of narrow regions | 0.6 | | Resolution of narrow regions | Off | | Maximum element growth rate | 1.45 | | Maximum element growth rate | Off | |
| Mesh (iv) (remaining) | Settings   | **Description** | **Value** | | --- | --- | | Maximum element size | 1600 μm | | Minimum element size | 1 | | Curvature factor | 0.5 | | Curvature factor | Off | | Resolution of narrow regions | 0.6 | | Resolution of narrow regions | Off | | Maximum element growth rate | 1.45 | | Maximum element growth rate | Off | |

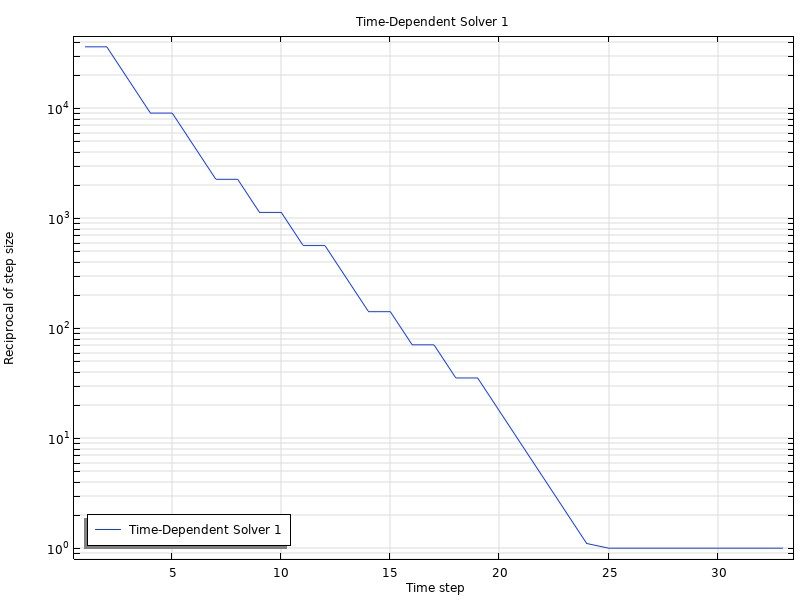
**SI.6 Time stepping and solver settings**

Fig. S5 Reciprocall time-step size in seconds vs the amount of time-steps.

An algebraic multigrid solver was used, with the BDF solver. Below an export of the solver settings from COMSOL.

Time-Dependent Solver 1 (t1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Time Dependent](#cs3550554) |
| Output times | {1.0E-6, 1.0E-5, 1.0E-4, 0.001, 0.01, 0.1, 1, 10} |

Time stepping

| **Description** | **Value** |
| --- | --- |
| Maximum BDF order | 2 |
| Error estimation | Exclude algebraic |

Algebraic multigrid Solver

Method and termination

| **Description** | **Value** |
| --- | --- |
| Damping factor | 0.9 |
| Jacobian update | Once per time step |
| Stabilization and acceleration | Anderson acceleration |
| Dimension of iteration space | 5 |
| Mixing parameter | 0.9 |
| Iteration delay | 1 |

Error

| **Description** | **Value** |
| --- | --- |
| Factor in error estimate | 20 |

Multigrid 1 (mg1)

General

| **Description** | **Value** |
| --- | --- |
| Solver | Smoothed aggregation AMG |
| Maximum number of DOFs at coarsest level | 50000 |
| Construct prolongators componentwise | On |
| Prolongator smoothing | Off |

Coarse Solver (cs)

Direct 1 (d1)

General

| **Description** | **Value** |
| --- | --- |
| Solver | PARDISO |
| Pivoting perturbation | 1.0E-13 |

**SI.7 Videos**

Capillary filling in channels with a width of 300 µm and height of 34, 60, 100 µm (Video S1, S2, S3); Stop valve during capillary filling (Video S4).

References

1 D. Ma, H. Chen, D. Shi, Z. Li and J. Wang, *J. Colloid Interface Sci.*, 2009, **332**, 85–90.