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A flexible method for rapid-prototyping of PDMS microfluidic chips for droplet based applications using direct-written polymer master structures

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We report a new, rapid and flexible method for molding of PDMS microfluidic chips. Conventional, time- and cost-consuming UV-lithographic fabrication of PDMS-molds is substituted by a direct-writing method using a water-based polymer solution. This technique facilitates on-demand prototyping and rapid change of master structures in a low-cost manner. No cleanroom and less expertise is required and time-to-chip is reduced from ~24 h to less than 4 h promoting application of microfluidic chips in biology- and chemistry-oriented laboratories.

A direct-writing method [1] is used to create polymer structures on low-cost polyimide (PI) substrates. A meniscus is established bridging a 200 µm-nozzle loaded with polyacrylic acid (PAA, 50 wt-%) and the substrate (Fig 1). Controlled displacement of the dispenser (PipeJet P9, BioFluidix GmbH) [2] allows creation of polymer lines via capillary flow. After water evaporation, PDMS can be casted on the fabricated structures. Dimensions of the PAA-structures amount to 100-300 µm in width and 6-12 µm in height. Stacking of structures realized by multiple writing runs leads to a linear increase in height up to 110 µm (Fig. 2).

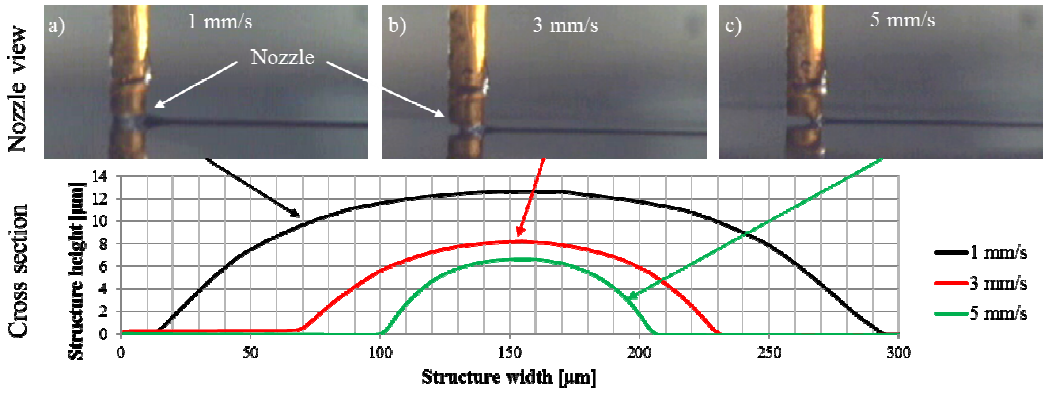

Fig. 1: View of nozzle during PAA-structure generation for different substrate displacement velocities of a) 1mm/s, b) 3 mm/s and c) 5 mm/s. Profiler-measurements demonstrate round cross sections of written structures for each displacement velocity.

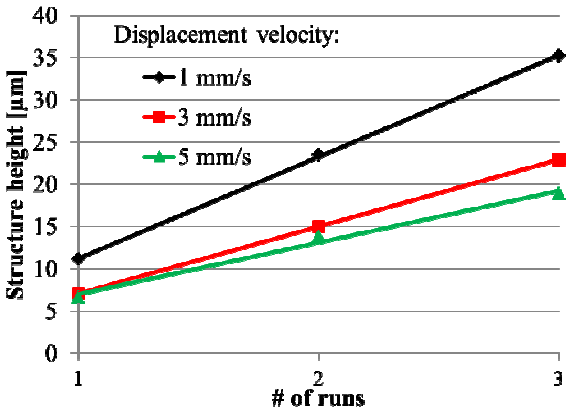

Fig. 2: The height of the structures depends linearly on the number of writing runs.

A microfluidic droplet generator has been fabricated in less than four hours to demonstrate the applicability of the reported method. Channels exhibit dimensions of 150 µm width and 35 µm height. At flow rates of 30 µL/h for water and 200 µL/h for two oil streams, constant droplet generation can be observed (Fig. 3) whereas the frequency amounts to 60 Hz with a single droplet volume of 15 pL.

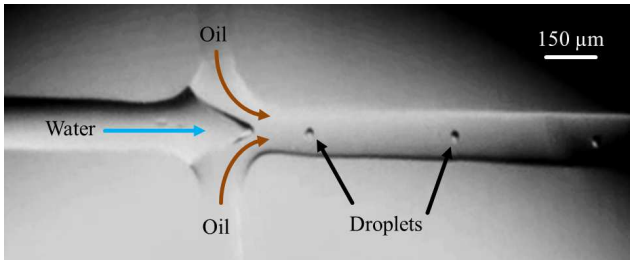

Fig. 3: Microfluidic droplet generator.

We have successfully demonstrated the rapid fabrication of a PDMS microfluidic chip in less than 4 hours. Future work will focus on tackling novel applications based on this platform technology like droplet based PCR chips enabling easy adaption of the fluidic design to the required thermocycling protocol.

[1] G. Gratson et al., Nature, 428, 386 (2004).

[2] W. Streule et al., JALA, vol. 9, pp. 300-306, 2004.

Keywords: rapid-prototyping, direct-written, PDMS-chips, droplet-based-microfluidics