Technical University of Denmark

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Garbarino, Francesca; Kistrup, Kasper; Rizzi, Giovanni; Hansen, Mikkel Fougt

Publication date:
2016

Document Version
Peer reviewed version

Citation (APA):
Garbarino, F., Kistrup, K., Rizzi, G., & Hansen, M. F. (2016). Burst Pressure of all-polymer phaseguide structures of different heights. Abstract from 20th International Conference on Miniaturized Systems for Chemistry and Life Sciences, Dublin, Ireland.

Topic No. 4.01

Abstract Reference No: 0140

Oral or Poster

Burst Pressure of all-polymer phaseguide structures of different heights

Francesca Garbarino, Kasper Kistrup, Giovanni Rizzi and Mikkel Fougt Hansen
Department of Micro- and Nanotechnology, Technical University of Denmark,
DTU Nanotech, Building 345 East, DK-2800 Kgs. Lyngby, Denmark

Phaseguide structures have proven very successful for the controlled filling of liquids in chambers and channels in microfluidic systems [1,3]. The phaseguide structures are usually introduced as ridges where the burst pressure of a structure can be determined by the angle to the channel sidewalls, via kinks or by inclusion of branches [2,3]. When the structures are defined using lithography techniques, phaseguides usually have the same height to keep the fabrication simple. However, when structures are defined by milling and fabricated by injection moulding, it is easy to modify the height of the structures while maintaining a constant geometry, but this has not been studied systematically.

We present an experimental investigation of the burst/overflow pressure of water in 90° phaseguide structures in a 3 mm wide injection moulded polymer channel as function of their height, h (Fig. 1). Structures with branches of angles α = 45°, 60° and 75° were studied.

The polymer chip consists of two parts: a main part of injection moulded cyclic olefin-copolymer (COC) polymer (TOPAS grade 5013L-10) and a 0.254 mm COC sheet (TOPAS grade 5013S-04) ultrasonically welded to the main part [4]. The chip layout featured three 3 mm wide channels (Fig. 1c) of height H = 200 μm with a sequence of phaseguides of height increasing from h = 20 μm to 100 μm (Fig. 1a, Table 1).

Hydrostatic burst pressures were measured by raising one end of a peroxide cured silicon tubing (OD= 10mm, ID=6 mm) filled with MilliQ water connected through the other end to the chip to a height Δz above chip level using a Thorlabs LTS150 motorized stage (Thorlabs, Newton, NJ, USA) (Fig. 2a). An experiment was performed by first adjusting Δz to zero. Then, the syringe was raised at 1 mm/s while carefully monitoring the position of the liquid meniscus in the chip. When the meniscus advanced in the channel, the stage was paused and the fluid allowed to pin at the next phaseguide (Fig. 2b) after which the stage motion continued. Measurements were performed on three different chips, which were then rinsed and dried before conducting another set of measurements. The burst pressure was determined as $p = \rho g \Delta z$ with ρ = 998 kg/m^3 and g = 9.82m/s^2.

Fig. 3 shows p (and Δz) as function of the relative height h/H of phaseguides with the indicated angles α of the branch. The results are reproducible and show the same variation for measurements performed on the same chip and between different chips. A linear dependence of p on h/H is observed with no significant dependence on α. The liquid was observed to always overflow at the branch and thus the main function of the branch for the investigated geometries was to control the overflow position.

The knowledge obtained in this study enables simple tuning of liquid spreading and overflow in microfluidic channels by use of phaseguide structures with different heights and it also provides a set of systematic experimental data to be compared with simulations/theory.

Word Count: 497

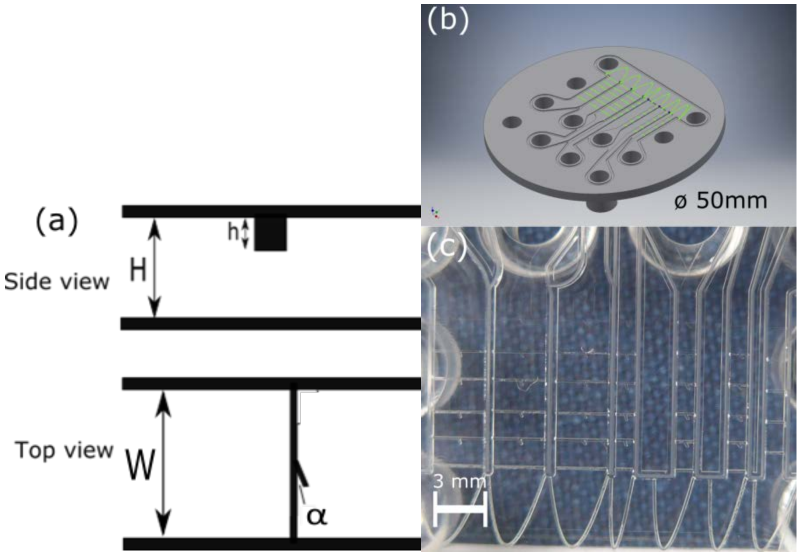

***Fig. 1**: **(a)** Top and side views of a channel (height H, width W) with 90° phaseguide structure (height h) including a branch at an angle α. **(b)** Layout of injection moulded chip with integrated Luer connectors. **(c)** Photograph of the fabricated chip prior to ultrasonic welding showing the parallel layout of the channels containing the phaseguides with branches.*

***Table 1:** Geometrical parameters of channel and phaseguide structures. Measured contact angle and surface tension of water.*

Parameter	*Values*
Channel height (*H*)	200 µm
Phaseguide height (*h*)	20;40;60;80;100 µm
Channel width (*W*)	3 mm
Phaseguide-wall angle	90°
Branch angle *α*	45°;60°;75°
Contact angle *θ*	96°
Surface tension *γ*	72 mN/m

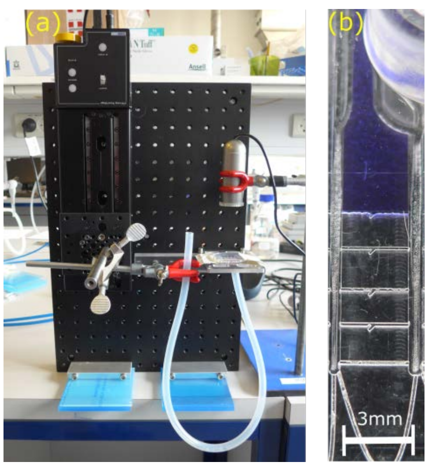

***Fig. 2:** (a) Setup used for measuring burst pressures (b) Photograph of 3 mm channel with MilliQ water and Brilliant Blue R dye [c=1.21 mM] pinned at the second phaseguide.*

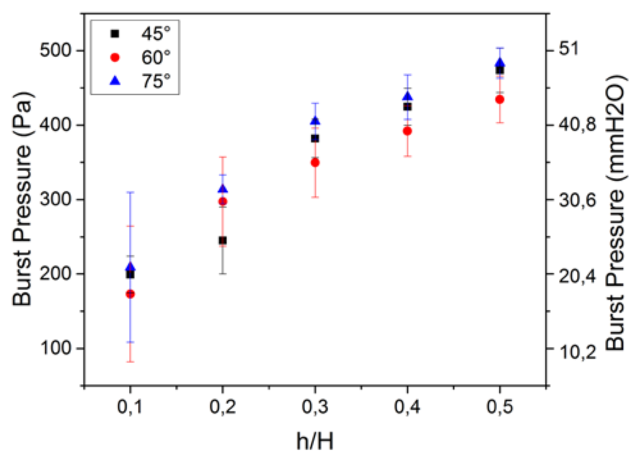

***Fig. 3:** Burst pressure p (left axis) and Δz (right axis) as function of h/H for phaseguides with branches at the indicated angles.*

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This work was supported by DFF projects 4005-00116 and 4184-00121.