# Can droplets count? Integrated microfluidic logic circuits

Piotr Korczyk[1*], Damian Zaremba[1], and Sławomir Błoński[1]

[1] *Institute of Fundamental Technological Research, Polish Academy of Sciences, ul. A. Pawińskiego 5B, Warsawa, Poland*
piotr.korczyk@ippt.pan.pl

Integration of numerous logic elements for encoding the sequences of digital operations into the structure of the device has been successfully implemented in electronics, becoming one of the pillars of the information revolution.

About one decade ago Manu Prakash demonstrated, that single fundamental logic operations can be implemented in the two-phase microfluidic flows due to the utilization of nonlinearity introduced by surface interactions [1]. Those findings raised a hope that further integration of these base units would enable construction of architectures inducing programmed cascades of digital operations on droplets or bubbles. That approach would pave the way for autonomous microfluidic systems with all analytical procedures hard-wired into the structure of the device. However, until now there is a lack of examples of realization of that promising idea.

Herein we show the new approach to the construction of microfluidic geometries, which perform the logic operations on sequences of droplets. We explain the working principles and, what is most important, we demonstrate that those single units can be successfully arranged into larger systems performing sequences of operations. Finally, we demonstrate the examples of encoding of the digital procedures of counting of droplets in both binary and decimal systems. In our microfluidic architectures, some of droplets flowing into the counter play a role of indicators and their positions correspond directly to the current count of all flowing droplets. Such microfluidic counters can be arranged in series to count a custom number of droplets. We show and test a few construction of the counters, which can count reliably up to 1000 droplets.

Presented devices show the fascinating aspect of microfluidics, where continuous flows of liquids crossed in microfluidic junction spontaneously transform into the discrete droplets and then these droplets perform digital computations.

## References

[1] Prakash M. and Gershenfeld N. *Microfluidic Bubble Logic*, Science, pp. 832–835, 2007.

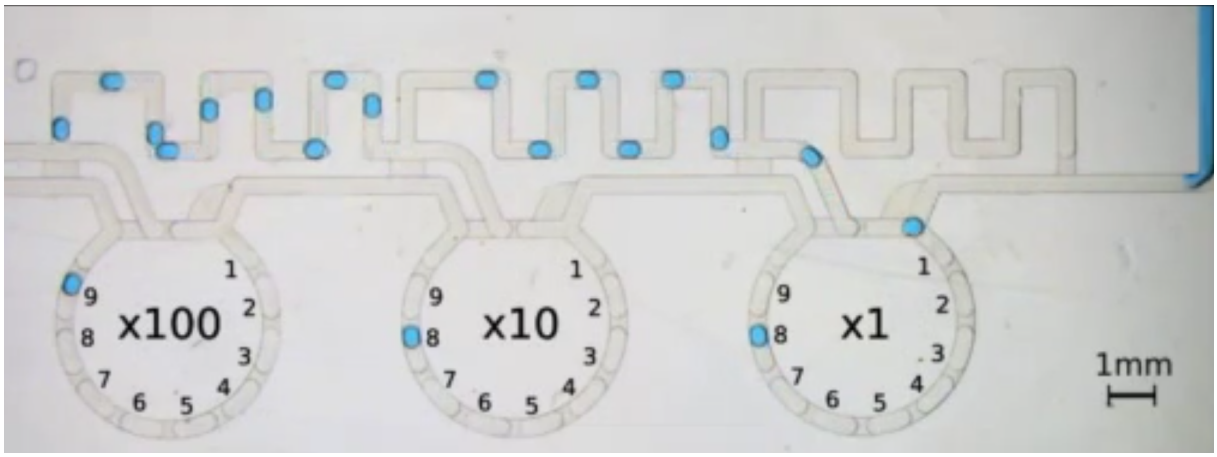


Figure 1: Microfluidic droplet counter. The image captured for the $988^{th}$ droplet as being indicated by the *display*.