# Model of a Microfluidic Thermal Cycler Activated By Means of Electro-osmotic Micro-pumps

Elena Bianchi[1,2], Maria Francesca Bello[1], Ida Critelli[1], Prof. Gabriele Dubini[1]

1. Politecnico di Milano, LaBS, Laboratory of Biological Structure Mechanics, Milano, Italy.
2. Swiss Federal Institute of Technology (EPFL), Laboratory of Life Sciences Electronics - Swiss Up Chair, Lausanne, Switzerland;

**Introduction**: Polymerase Chain Reaction (PCR), a well known procedure in molecular biology able to amplify and simultaneously quantify a targeted DNA molecule by a thermal cycle.
Electro-osmosis (EO) is an electro-kinetic phenomenon expressed when a polar fluid and a solid surface are exposed to an electrical field. EO pumps are advantageous in microfluidic because of their compactness and the absence of moving parts [1,2].

**Computational Methods:** 3D model of different pumps configurations have been set (Fig. 1). An electroosmotic velocity has been imposed to each wall, following the Helmotz-Smoluchowski equation:

$$V_{EOF} = \frac{\zeta \cdot \varepsilon \cdot E_{EL}}{\mu}$$

The downstream pressure is a function of the flow-rate and of the hydraulic resistance faced by the pump if connected to the loop. The loop with the pumping boundaries is a 2D time dependent simulation with a proper sequence of activation for couples of pumps. Shallow channel approximation considers the effect of the thickness of the channel by a volume forces term.

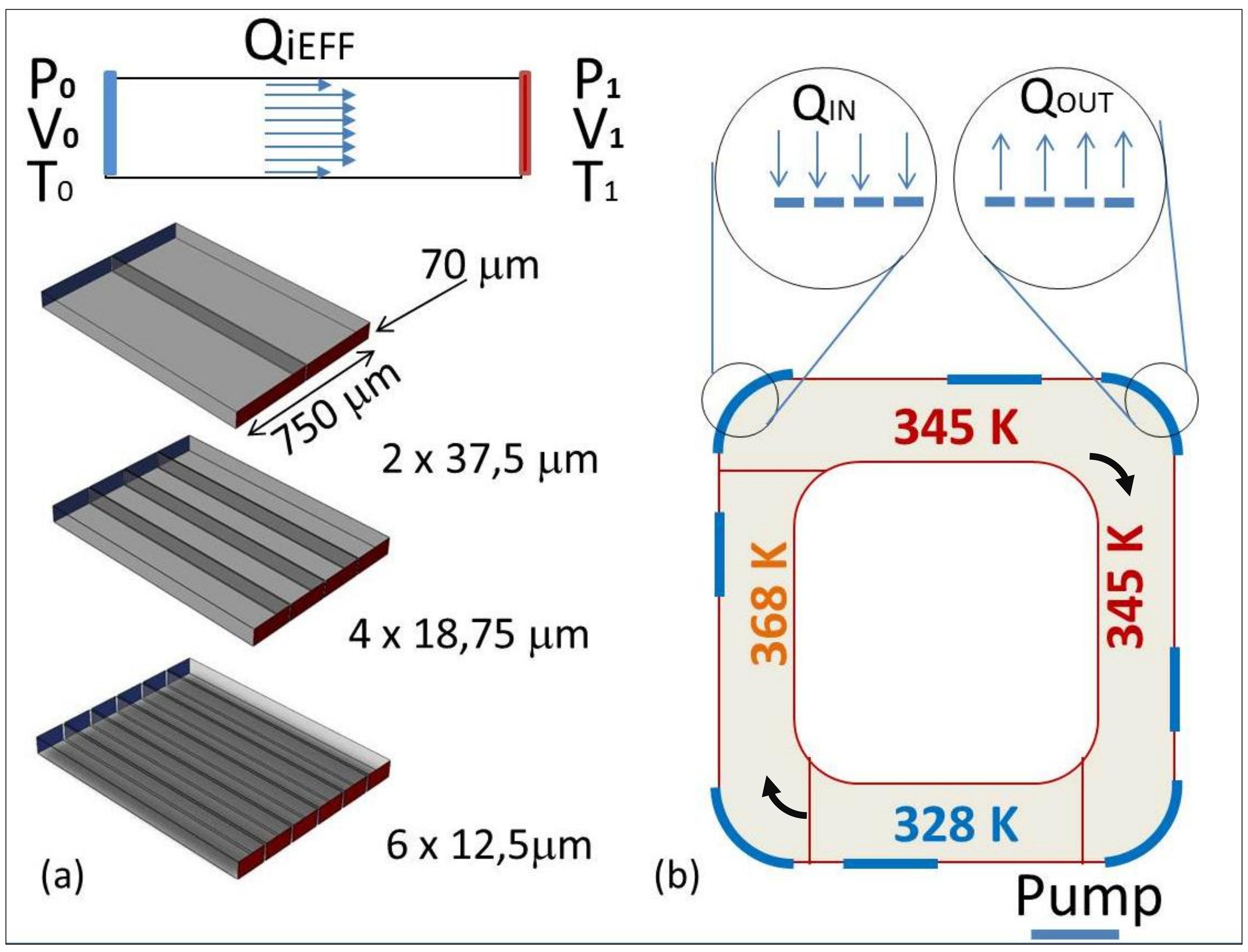


**Figure 1**. Boundaries condition for each channel; multiple channel configurations (b) 2D model of the device: the position of the pumps an the temperatures zones are indicated.

**Results**: The six-channel-configuration has been selected and implemented into the 2D model of the fluidic loop: it show the highest $Q_{IN}$ = 1,8 µL/min and a time to cycle of ~50 s.

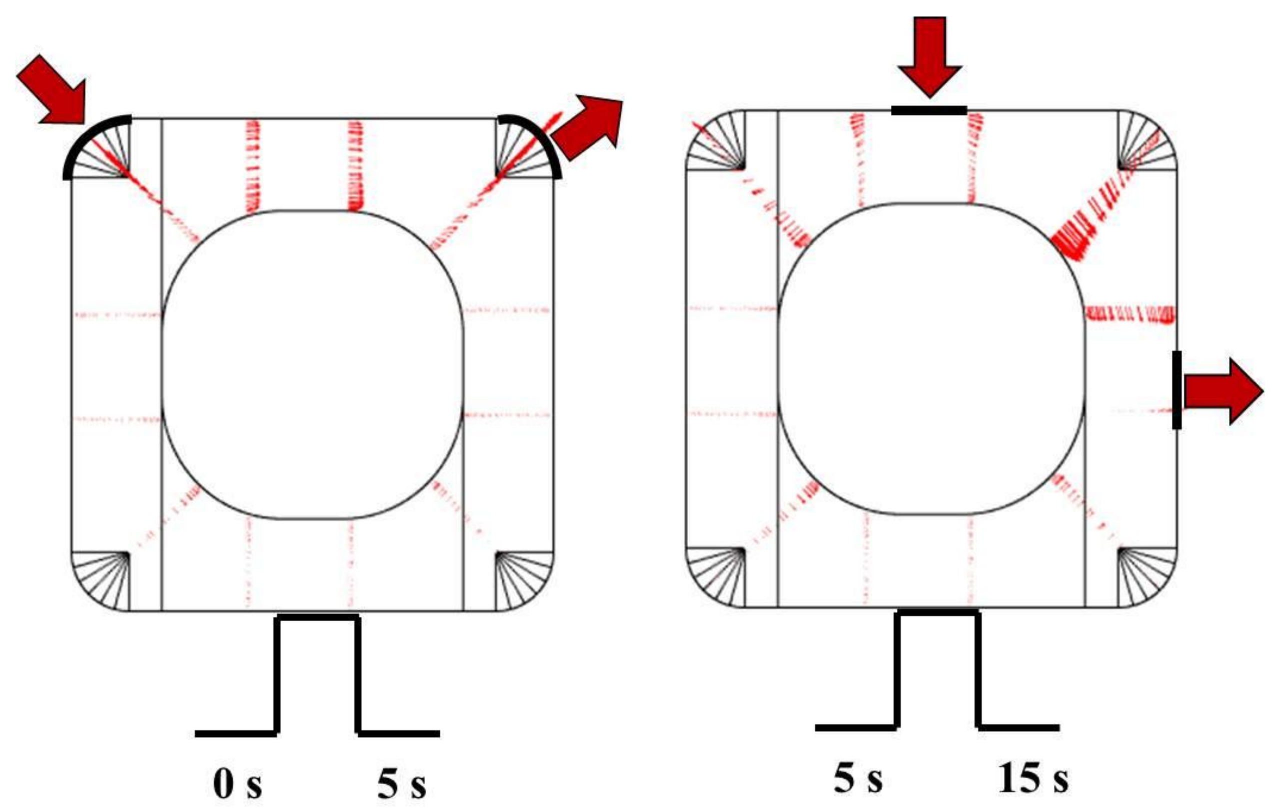


**Figure 2**. a) Sketch of the entire device; b) Activation timing for the two consecutive couples of pumps. Vectors represents the velocity of flow on selected channel sections (not to scale).

**Conclusions**: Results of the simulations show a consistent performance of the micro-thermo-cycler in term of continuity in time and directionality. It allows to avoid the direct immersion of a biological sample in the electric field. Furthermore it does not require external pumps.

1.Wang, X., et al., Electroosmotic pumps and their applications in microfluidic systems. Microfluidics and Nanofluidics, 2009. 6(2): p. 145-162.
2.Brask, A., G. Goranović, and H. Bruus, Theoretical analysis of the low-voltage cascade electro-osmotic pump. Sensors and Actuators, B: Chemical, 2003. 92(1-2): p. 127-132.