Analysis of Fluid Pumping with a Throttle Type Piezoelectric Micro Pump

Borut Pečar[1*], Dejan Križaj[2], Danilo Vrtačnik[1,3], Drago Resnik[1,3], Matej Možek[1,3], Uroš Aljančič[1,3], Tine Dolžan[1], Slavko Amon[1,3]

[1]University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Microsensor Structures and Electronics, Tržaška 25, SI-1000 Ljubljana, Slovenia

[2]University of Ljubljana, Faculty of Electrical Engineering, Laboratory for Bioelectromagnetics, Tržaška 25, SI-1000 Ljubljana, Slovenia

[3]Centre of Excellence Namaste, Jamova 39, SI-1000 Ljubljana, Slovenia

Introduction: Micropumps are becoming an essential part of many microfluidic devices e.g. micro TAS (total analysis systems) also called labs on chip [1, 2]. Operation of a modified type (called strip type due to rectangular shape of an actuator) of throttle type micro pumps is analyzed by finite elements numerical simulation. A complete 3D model of a pump has been developed and solved using coupled electro – fluid – solid mechanics approach.

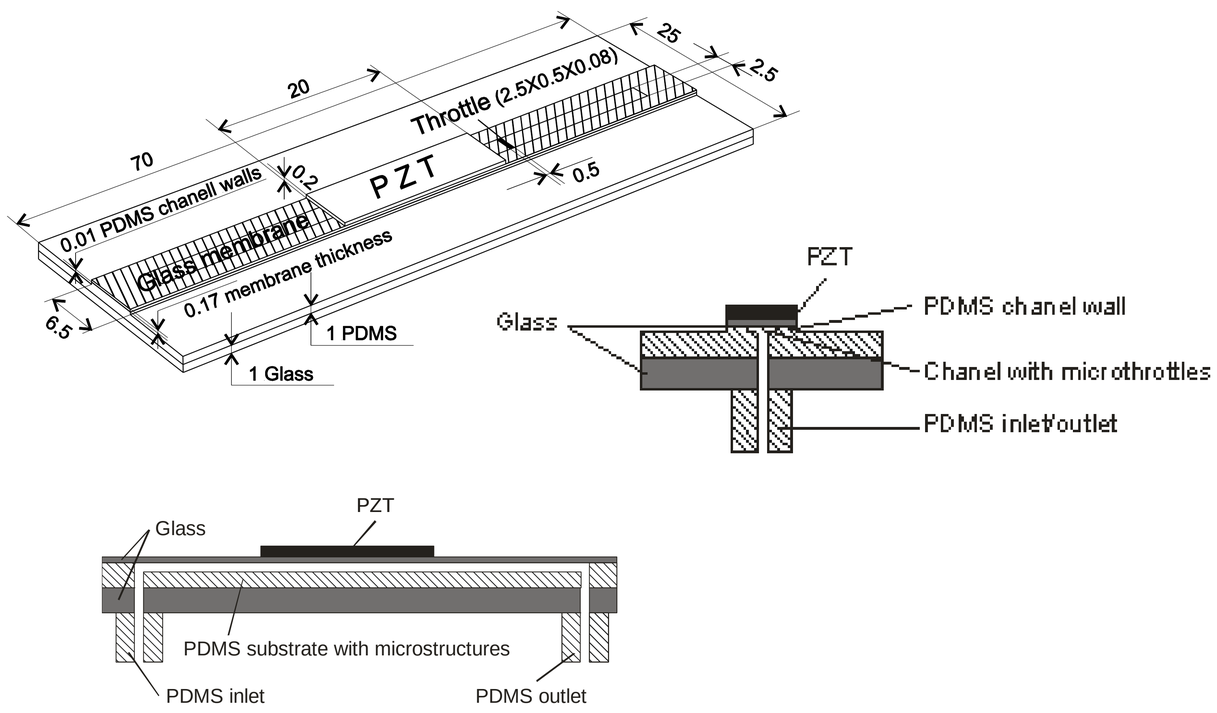

Figure 1. Top: 3D model with dimension details of a of a simulated structure. Middle and bottom: cross-section of a structure (dimensions not to scale).

Strip type micro throttle pump: The pump is composed of a PDMS substrate bonded onto a supporting bottom glass. PDMS channel walls and two throttles (valves that during operation do not completely close) are extruded on the top of the substrate and covered (bonded) by a thick glass membrane. On top of the membrane is a PZT actuator driven by a sinusoidal voltage signal.

Simulations: Fluid-flow is modeled by Navier –Stokers equation simplified to a creeping flow model. Deformation of a membrane due to piezoelectric actuation is modeled by coupled electro – structural mechanics model. Optimized meshing has been achieved by tuning the parameter Resolution of narrow regions.

Results: Due to difference in the shape of membrane deflection close to the throttles a positive total fluid volume flow is achieved after one time period. Simulations revealed throttle positions resulting in maximal pumped fluid volume.

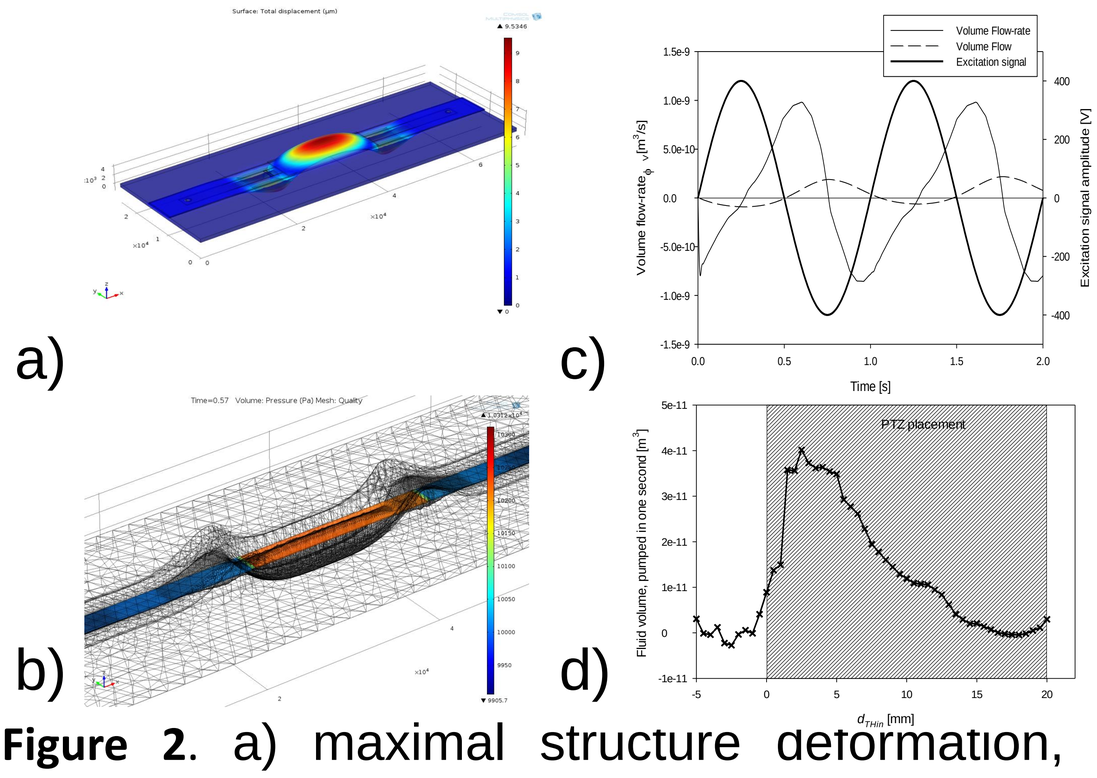

Figure 2. a) maximal structure deformation, b) distribution of pressure in the cavity, c) time evaluation of fluid flow rate at outlet and total pumped fluid volume, d) optimization of throttle position. .

Conclusion: Numerical simulations have been found very useful for understanding of device operation and optimization of geometrical parameters.

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