Design and Simulation of a Piezoelectric Actuated Valveless Micropump

J. J. Rojas[1], J. E. Morales[2]

[1]School of Electromechanical Engineering, Instituto Tecnológico de Costa Rica, Cartago, Costa Rica
[2]School of Electronic Engineering, Instituto Tecnológico de Costa Rica, Cartago, Costa Rica

Abstract

Microfluidics is a multidisciplinary field, basically it designs systems to handle small volumes of fluids. Some of the applications are inkjet print heads, DNA chips, lab on chip technology, micro-propulsion, drug delivery, and micro thermal technology.
Most of microfluidic applications require a pumping action in order to move the fluid trough the system. Some applications can make use of surface tension, macroscale pumps, positive or negative pressure chambers or other methods to transport the fluid. Yet, for most applications a micro scale active pump is highly desirable.
In this work, we design and simulate a valve less, diaphragm-based, piezoelectric micro pump. A 3D model of the pump is showed in Figure 1. The piezoelectric actuator is a PZT-5H piezo-disk, the diaphragm is a borosilicate glass plate.
All the simulations were made using COMSOL Multiphysics® software. First, the piezoelectric actuator and membrane thicknesses are chosen by means of a stationary simulation, using the piezoelectric devices module we simulate the deformation of the membrane under different voltages, using different combinations of the membrane and piezo actuator thicknesses. From the obtained results (as showed in Figure 2.) we decided to use a 100 µm membrane and a 50 µm piezo actuator.
Using this geometry we build a simplified symmetric 3D model to be used in the pump simulation (Figure 3.). A complete system simulation with one way coupling between the piezoelectric devices module and the fluid structure interaction module was made. Is considered to have no back-pressure. The results obtained for inlet and outlet flow are showed in Figure 4.

Reference

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S. Li and S. Chen, “Analytical analysis of a circular PZT actuator for valveless micropumps,” Sensors and Actuators, A: Physical, vol. 104, no. 2, pp. 151–161, 2003.

Figures used in the abstract

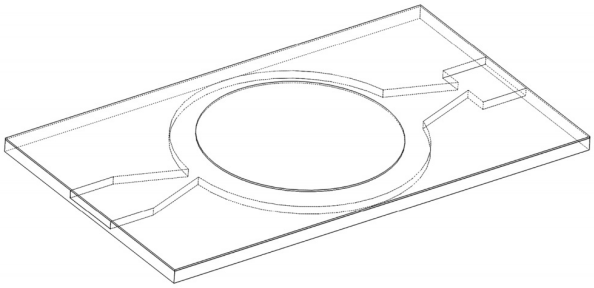

Figure 1: 3D model of the pump

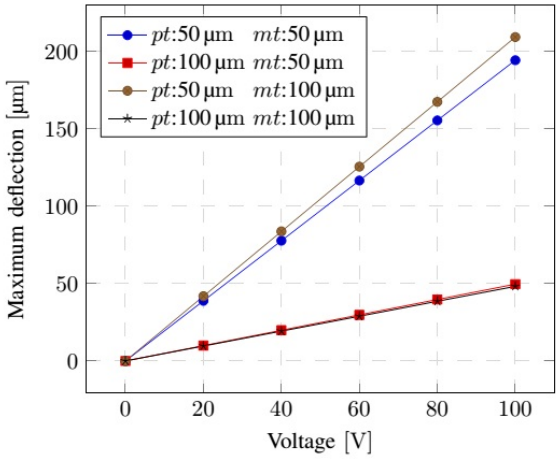

Figure 2: Maximum deflection of the membrane under variable applied voltage for four different conditions. Here, pt: piezoelectric thick, and mt: membrane thick.

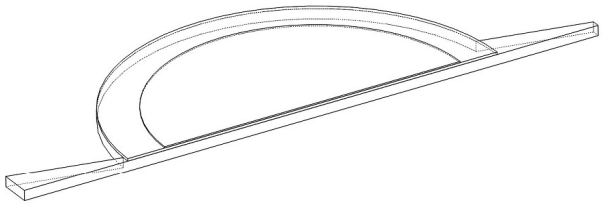

Figure 3: Simplified symmetric 3D model of the pump.

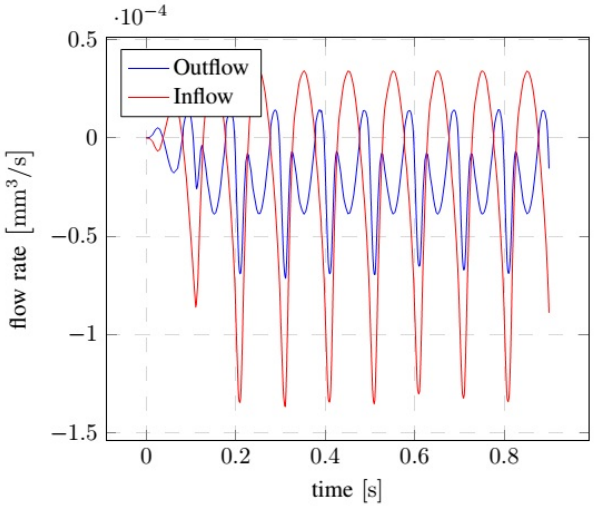

Figure 4: Flow rates at 50Hz and 20V.