# Design and Simulation of a Piezoelectric Actuated Valveless Micropump


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**Introduction**: Microfluidics is a multidisciplinary field, basically it designs systems to handle small volumes of fluids. Most applications require a pumping action in order to move the fluid trough the system. For most of them a micro scale active pump is highly desirable. A piezoelectric micropump is modeled, the actuator is a PZT-5H piezo-disk and the diaphragm is a borosilicate glass plate. COMSOL Multiphysics was used to choose the right membrane to piezo thickness relation and to simulate the pumping system under a sinusoidal voltage applied to the piezo actuator.

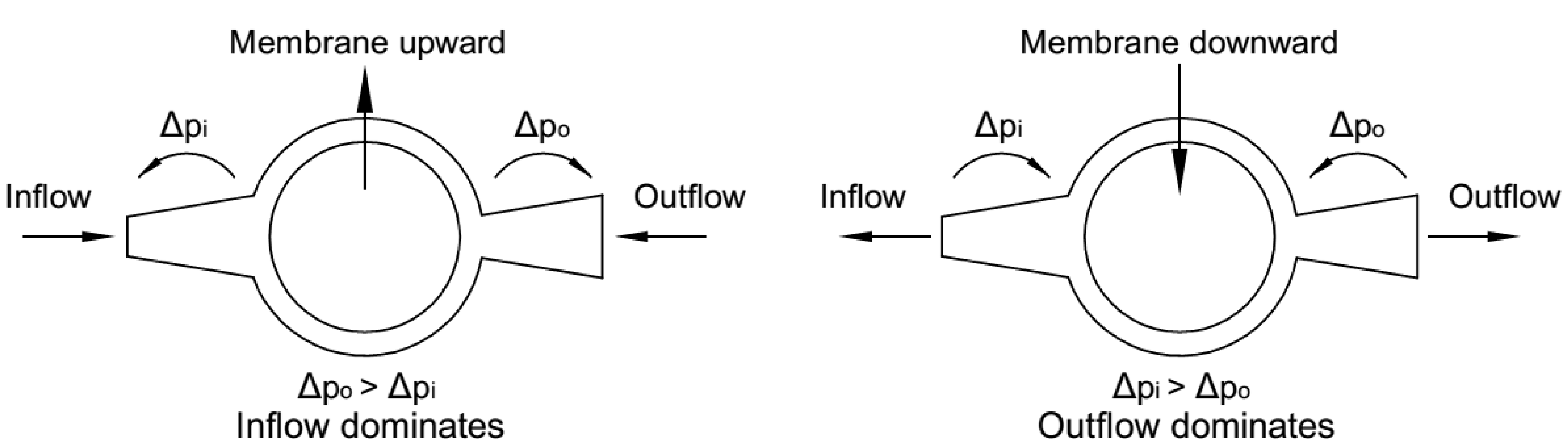


**Figure 1**. Principle of operation

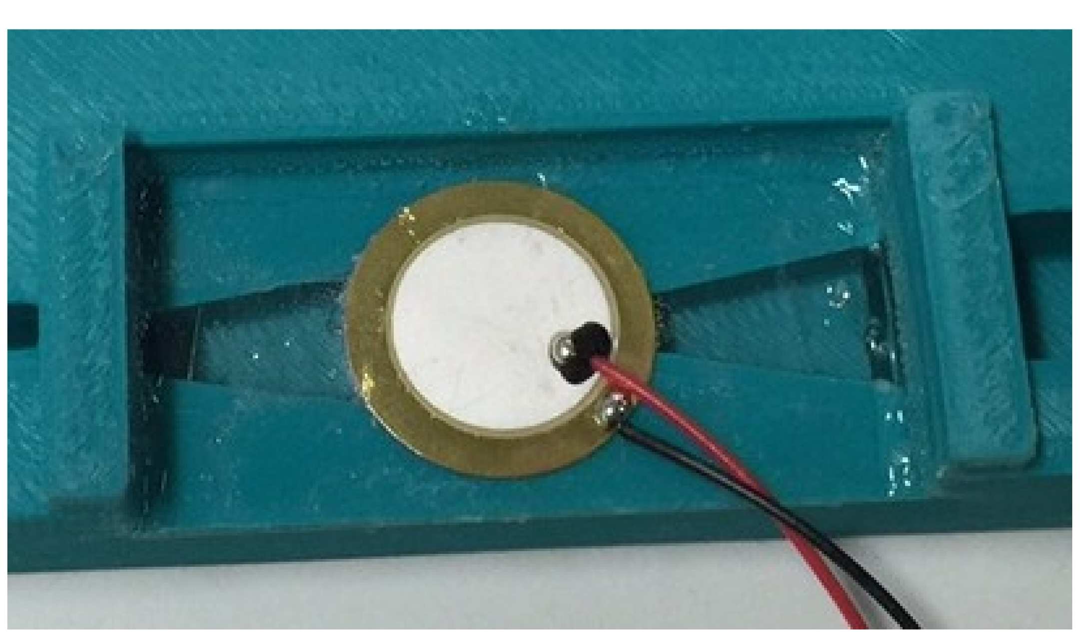

**Figure 2**. 3D printed prototype under development

**Computational Methods**: Solid mechanics (*solid*), electrostatics (*es*) and fluid structure interaction (*fsi*) were used to simulate the fluid motion in the pump. The piezoelectric effect was used, but it was necessary to manually add a coupling between *solid* and *fsi.* Two different studies were used, one for *es* and *solid*, and the other for *fsi* using the not-solve variables from previous study, in this way, a one-way coupling was achieved.

$$\rho\left(\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u}\cdot\nabla\mathbf{u}\right) = \nabla\cdot[-p\mathbf{I} + \eta(\nabla\mathbf{u} + (\nabla\mathbf{u})^T)] + \mathbf{F}$$

$$\nabla\cdot\mathbf{u} = 0$$

$$\nabla\cdot\mathbf{D} = \rho_v$$

$$\mathbf{E} = -\nabla V$$

$$S_{ij} = s^E_{jk}T_k + d_{kj}E_k$$

$$D_i = d_{ij}T_j + \epsilon^T_{ij}E_j$$

$$\rho\frac{\partial^2\mathbf{u}}{\partial t^2} - \nabla\cdot\boldsymbol{\sigma} = \mathbf{F}_v$$

**Results**: A parametric study was made to determine the best geometry of the pump (Figure 3), from this data, a 100 µm membrane and a 50 µm piezo disk were chosen. Then the complete flow motion simulation was made using a frequency of 30Hz and a voltage of 30V, inlet and outlet flow rates, netflow and pumped volume are showed on Figures 4 and 5. Figure 6 shows the differences in pressure drop during the downward cycle. The average flow rate of the pump under this conditions is 8.95 mm³/s.

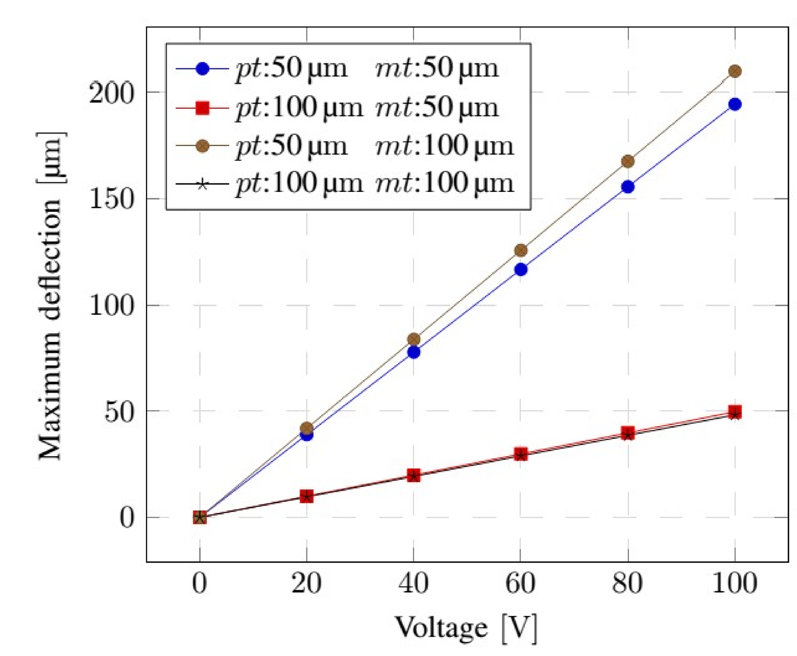


**Figure 3**. Maximum deflection at different combinations of piezo (*pt*) and membrane (*mt*) thickness.

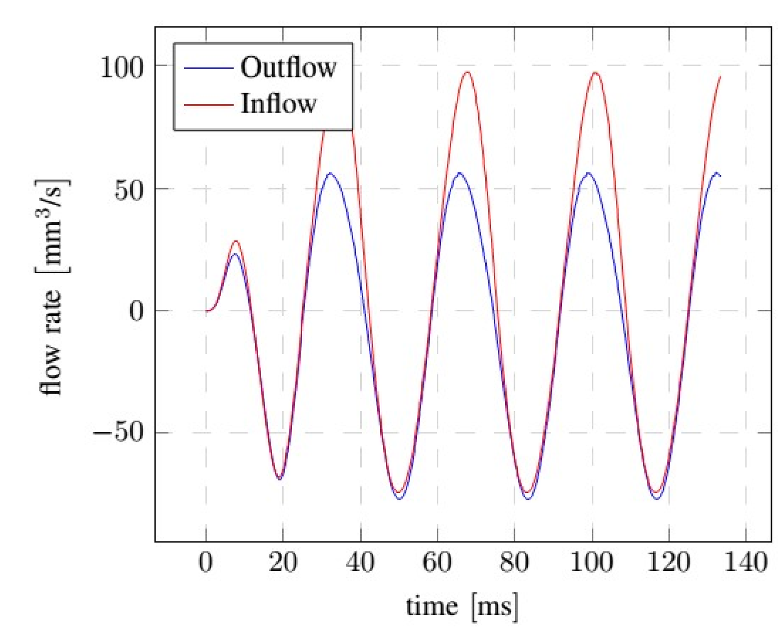


**Figure 4**. Flow rates, ƒ=30Hz, V=30V

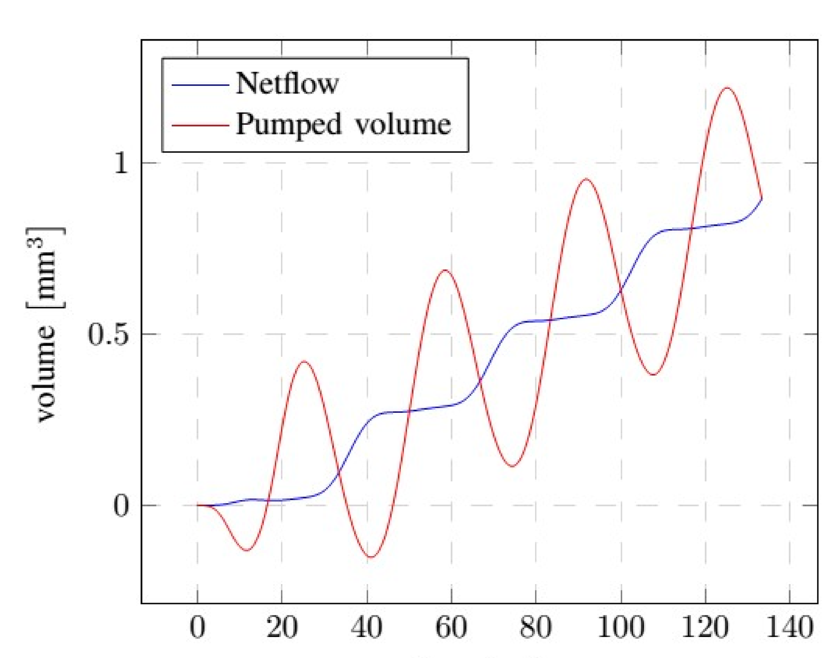


**Figure 5**. Netflow and pumped volume, ƒ=30Hz, V=30V

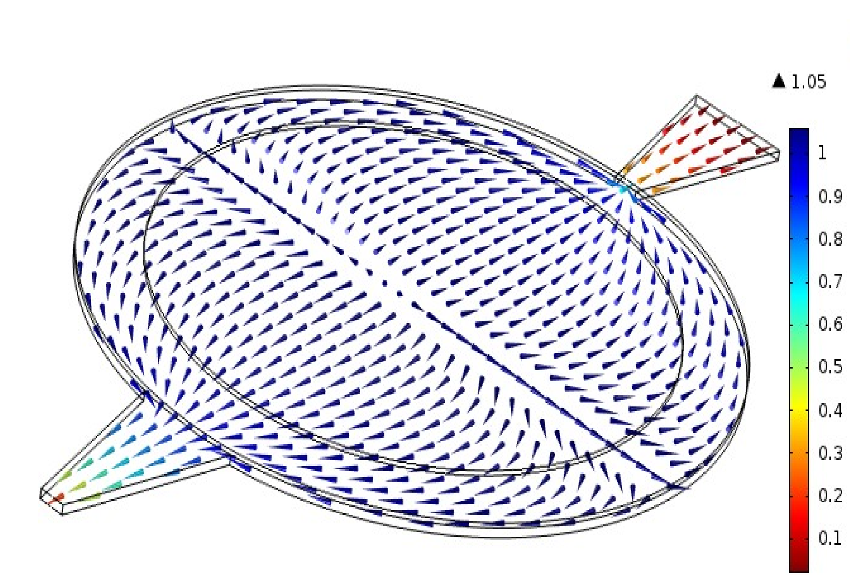

**Figure 6**. Pressure in kPa in the downward movement

**Conclusions:** A one-way coupled simulation of fluid motion in a piezoelectric valveless pump was successfully made using COMSOL. The prototype pump is under development and will be used to obtain experimental data in order to verify the results.

**References**:


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