Design and Simulation of MEMS Based Piezoelectric Insulin Micro-Pump

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Introduction: The MEMS based positive displacement Insulin Micro-Pump has a Piezoelectric Actuator on top of a Diaphragm membrane made from Silicone glass. Induced vibrations from PZT actuator create positive/negative volume in the pump's main chamber, which pull fluid from Inlet gate and push it toward outlet gate with the action of check valves.

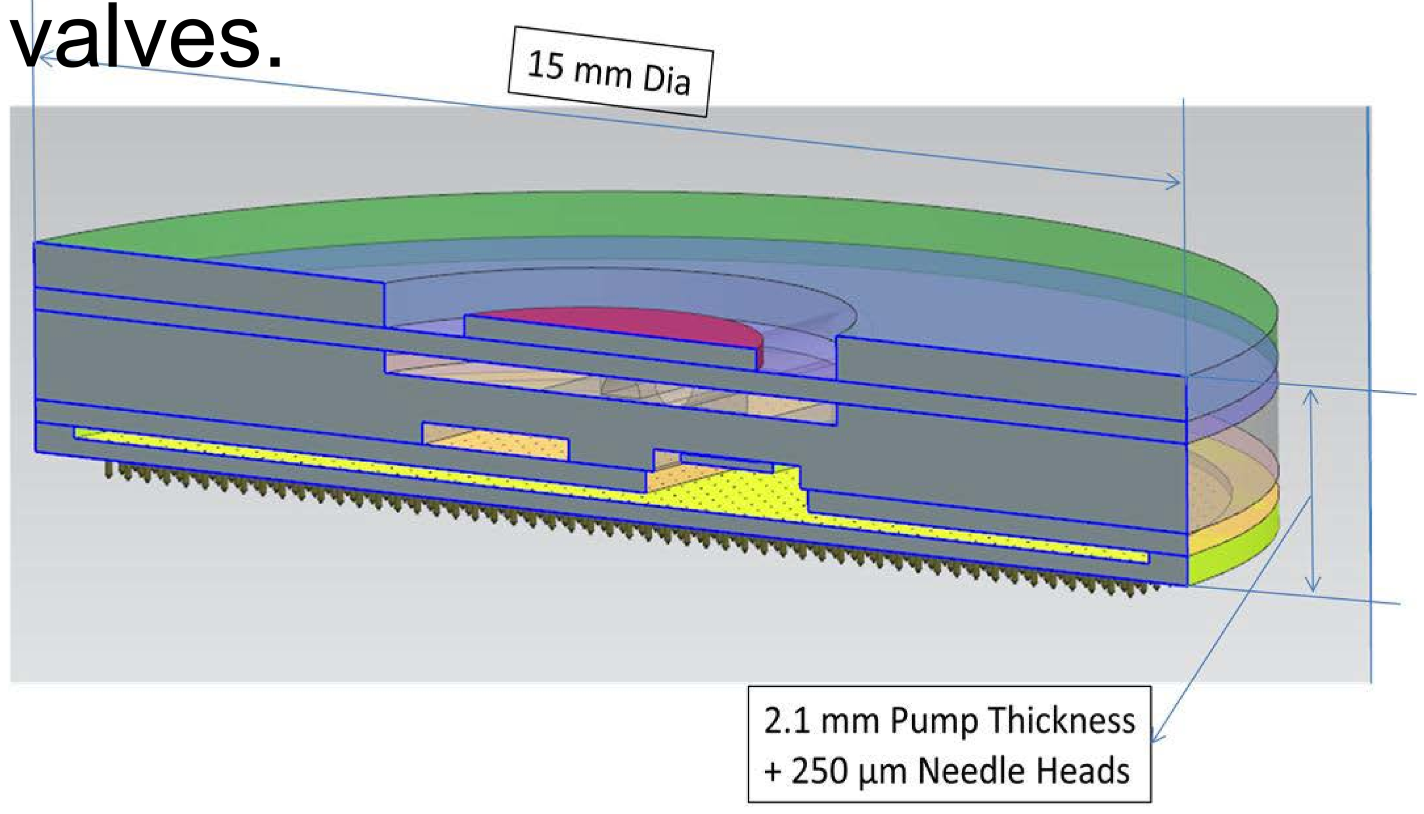

Figure 1. MEMS based PZT Micro-Pump

Computational Methods: Three COMSOL modules; Structural Mechanic, Piezoelectric Device and Fluid-Structure Interaction were used to study the 2-D/3-D models of Micro-Pump. Moving fluid-mesh follows solid deformation. The fluid flow is described by the Navier-Stokes equations with laminar incompressible Newtonian flow and free boundaries at the inlet and outlet:

$$\rho\frac{\partial \mathbf{u}}{\partial t} + \rho\mathbf{u}\cdot\nabla\mathbf{u} = -\nabla p + \nabla\cdot\mu(\nabla\mathbf{u} + (\nabla\mathbf{u})^T)$$

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

Figure 2 represents a 2-D layout of the Micro-Pump.

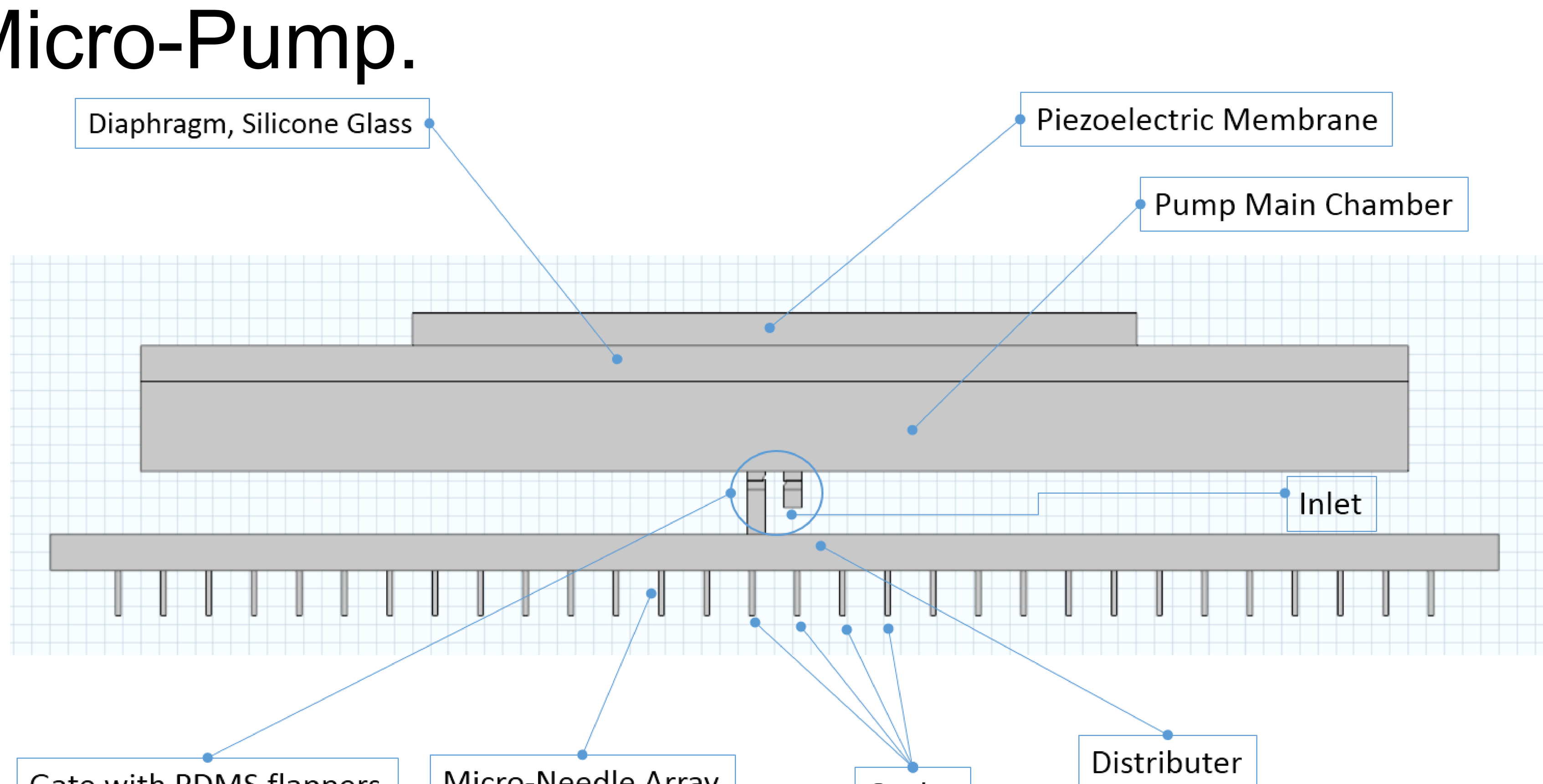

Figure 2. Micro-Pump 2-D layout.

Results: The Micro-Pump COMSOL model used to study the behavior of this pump for different input voltages (10 to 110 volt) with different input exciting frequencies (1 to 3 Hz). Figures 3 to 6 show some of the performance outputs @ V=110 Volt and Frequency = 1 Hz.

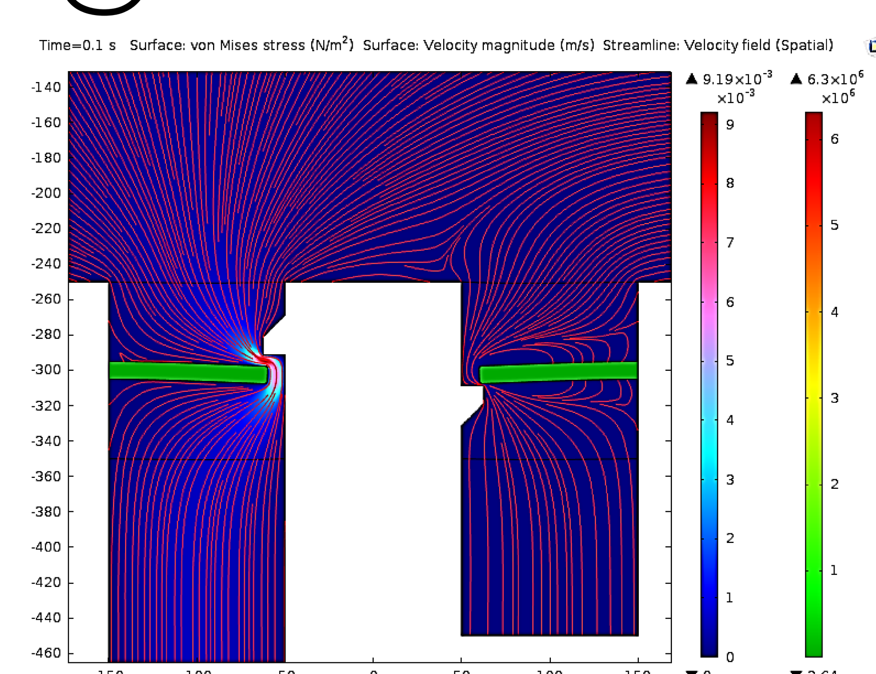

Figure 3. Flapper Check Valves -Von Mises stress & Velocity magnitude

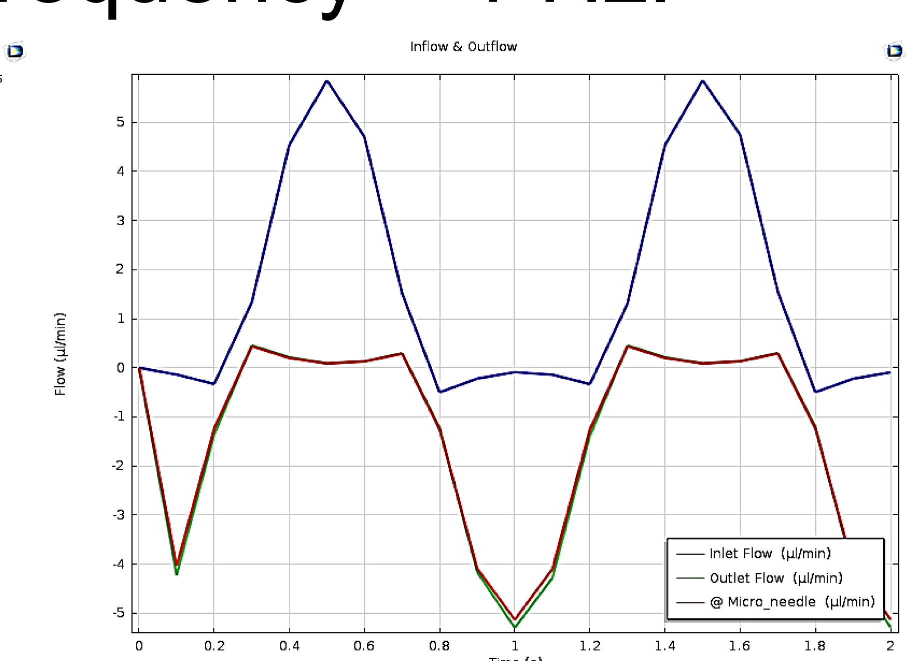

Figure 4. Inflow/Outflow Rates

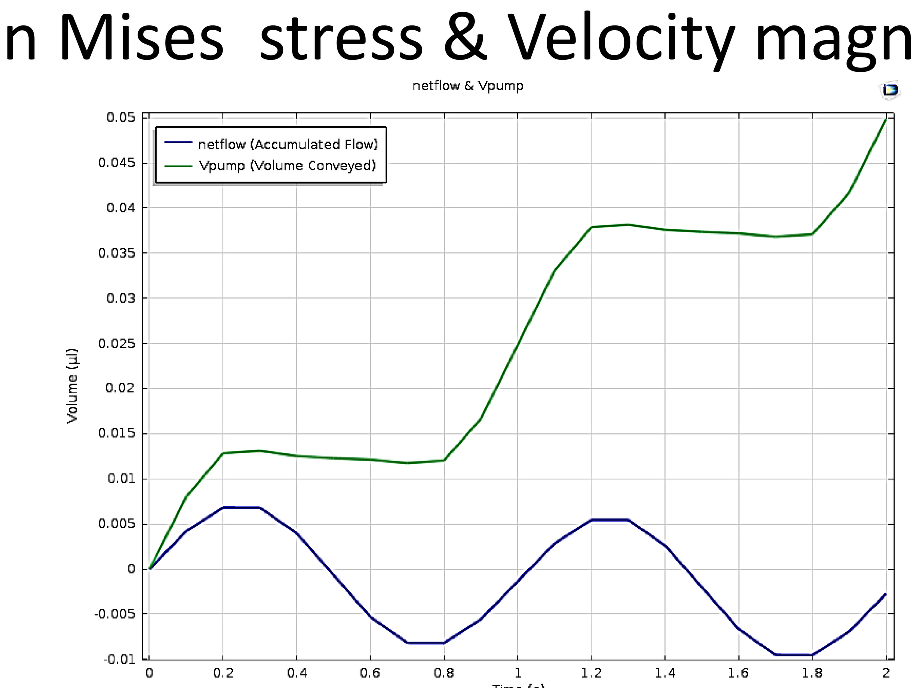

Figure 5. netflow and Vpump Volumes

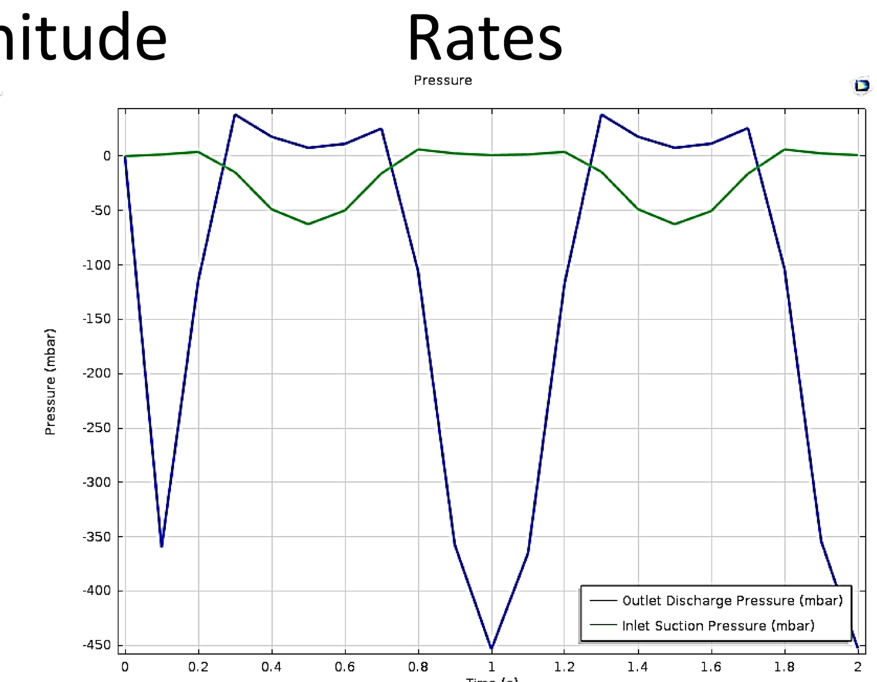

Figure 6. Inlet/Outlet Pressures

Conclusions: A parametric computational model of MEMS based Insulin Micro-Pump was developed, using COMSOL Multiphysics. It was used to study the pump performance under different inputs. The design seems acceptable for application of Insulin injection. Micro-Pump performs correctly from the Min to Max spectrum of pressure and flow rates.

References:

1. Bin Ma, Sheng Liu, Zhiyin Gan1, Guojun Liu, Xinxia Cai, Honghai Zhang, Zhigang Yang., "*A PZT Insulin Pump Integrated with a Silicon Micro Needle Array for Transdermal Drug Delivery*, Electronic Components and Technology Conference, (2006)

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