

# Design and Simulation of MEMS Based Piezoelectric Insulin Micro- Pump

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## Abstract

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Today, there are more than 10 million Canadians living with diabetes or prediabetes. With more than 20 Canadians being newly diagnosed with the disease every hour of every day, chances are that diabetes affects you or someone you know. Traditional method of injecting insulin is inefficient and painful with several side effects. One of the most effective treatment for diabetes type 1 and 2 is the application of Insulin pumps. Yet single needle mechanical insulin pumps are heavy and painful, Micro-Needle based MEMS technology can be an excellent solution for new generation of this type of drug delivery devices. Although this concept is specifically designed for, Insulin injection but it can be used for any other Micro-Drug-Delivery system. The stackable structure provides minimum dimensions and makes the final product to be patchable in any flat area of human skin and in combination with Micro-Needle Array; it provides a safe, painless and robust injection application.

The MEMS based pump has a Piezoelectric Actuator right above a Diaphragm membrane made from Silicone Glass. Introduced Vibration from PZT actuator creates positive/negative volume in the pump main chamber, and that pulls fluid from Inlet gate and pushes it toward outlet gate. The gating process is governed by two PDMS Flapper Check Valves that controls the fluid direction. A distributor connect outlet gate to micro-needle substrate, and finally the established back-pressure pushes the fluid out of Silicone micro-needle to Skin Dermis layer at slightly above atmospheric pressure. The general dimensions of the pump with substrate structure is up to 15 mm in Diameter and 2-3 mm in height (thickness). The designed hollow micro-needles are 200 $\mu$ m in length and 30 $\mu$ m in diameter at the pitch of 250 to 500  $\mu$ m.

Three COMSOL Multiphysics® interfaces; Solid Mechanics, Piezoelectric devices and Fluid-structure Interaction were used to model this MEMS based concept. Coupling physics provides real time relationship between different parameters and pump's outputs. Post processing and ODE also are used to create different charts and graphs.

Micro-Electro-Mechanical-System (MEMS) technology provides novel means in terms of both micro needles array and PZT pump, with safe and painless delivery, minimizing the size of the pump. Micro-Needles array has many advantages, including minimal trauma at penetration site due to the small size in needle, no condition limit, painless drug delivery for penetration depth with few nerves, and precise control of penetration depth for Micro-Needles extension length. The Micro-Needles array drug delivery is precise, painless, effective, clean and neatness, without

any inconvenience.