Characterization of an Intelligent Micro-Sensor/Pump by Stroke Volumes and Flow Rates

Authors: Bashar Hammad and T.C. Yih
The University of Texas at Arlington

A MEMS (micro-electro-mechanical systems) micropump with circular bossed membrane designed for nanoliter drug delivery is characterized in this article. A quasistatic model under consideration of low operating frequency is used to characterize this micropump. The mathematical model is an ordinary differential equation that describes the behavior of the micropump by including its key components of bossed membrane and inlet/outlet microvalves. Characterizations of bossed membrane and microvalves are carried out separately in the finite element analysis ANSYS package. The stroke volume of the membrane is calculated within the range that the linear deflection theory is valid. Analysis of the microvalves is a challenging task in microfluidics because it is a coupled field (solid-fluid coupling) problem. To solve the structural (solid) or fluid part separately is impractical in characterizing drug-delivery micropumps. Based on sequential weak solid-fluid coupling in ANSYS/FLOTRAN, the flow rates across the inlet and outlet microvalves are analyzed and simulated. Because the quasistatic equation contains several nonlinear terms, closed-form analytical solution for this equation is impossible; thus MATLAB is used to solve it numerically. The transient flow rate of the micropump is obtained by substituting the pressure in microchamber into the flow rate function of outlet microvalves. Integration of the function over 1 driving cycle and multiplication by the driving frequency provides the drug-delivery rate of the micropump.